

Progress Report of Forest Research Work in India

For the Year 1922-23

Including the Administration Report of the
Forest Research Institute, Dehra Dun.



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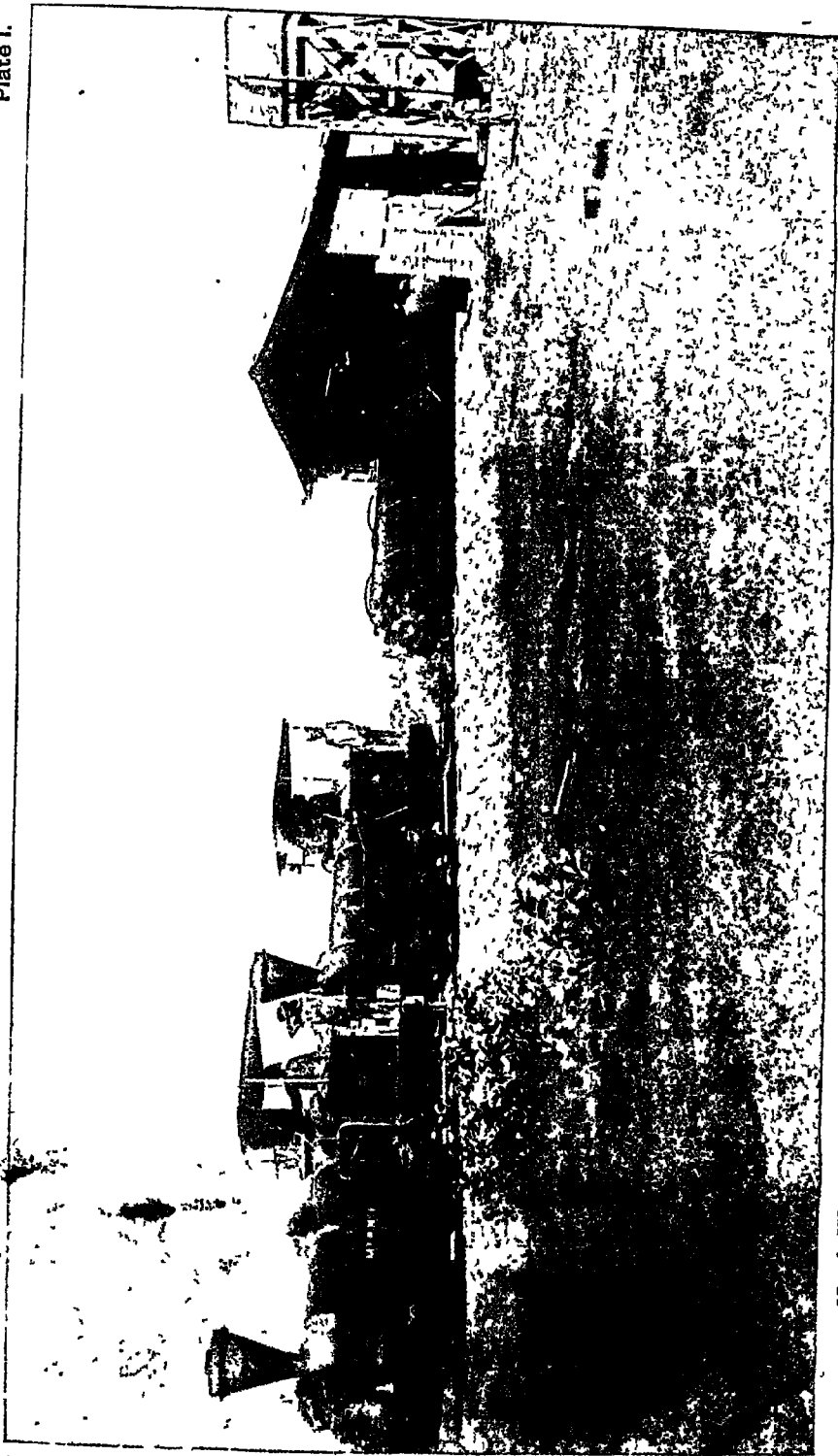
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North Western Railway crosscutting plant, Dhilyan (Beas). Sleepers being removed from cylinder on trucks.

Progress of Forest Research in India, 1922-23.

CHAPTER I.

GENERAL.

Throughout the year progress continued to be hampered by the general financial stringency, which, both in Provinces and in the Central Institute, forbade the filling of research posts and the expenditure of adequate funds for research purposes. The recommendations of the Incheape Committee at one time threatened the Central Institute with a serious curtailment of its activities ; and at Dehra Dun the year closed in an atmosphere of gloom, which happily has since been very greatly lightened. However, the following pages will show that, in spite of adverse circumstances, considerable progress has been made. At the Central Institute the whole of the buildings of the Economic Branch at the new site were practically complete by the end of the year, and the machinery was being installed. The whole Branch is expected to be in full working by November 1923, when the new water supply will be ready. The main building of the new Institute has not yet been started, nor have the buildings of the Entomological Branch.

The Section of Wood Preservation has not yet been properly constituted owing to the financial uncertainty. The plant has been erected, and some experiments have been made by the assistant staff under Mr. Pearson's guidance ; and it is now hoped that an expert will be obtained to take charge of the section by the end of 1923. The importance of this branch of the Institute's work was touched upon in last year's report, and it is gratifying to be able to record that this is being increasingly realised by the public and in particular by the railway administrations.

The number of enquiries received, especially in the Economic Branch, continues to increase ; and indeed now taxes the powers of the office to the full to deal with them. Some of the enquiries are more amusing than useful ; others credit the Institute with an omniscience which is far from claiming ; but the bulk of them are directed to practical purposes, and the fact that they continue to increase shows that the work of the Institute is becoming more and more widely known and appreciated. It is greatly to be regretted that for financial reasons it was found necessary to close down the Minor Products Section at the end of 1922. Provision is however being made to re-open it in 1924. There is a very large field of enquiry open to this Section, and moreover, without it the Chemical Branch cannot be utilized to the full.

Silviculture, the bed-rock of all forest management, is dealt with fully in Chapter II, which shows a gratifying activity on the part of many of the Provinces. The Silvicultural Branch at the Central Institute suffered from shortage of staff throughout the year; but it is hoped that this will shortly be remedied and that the Branch will be in a position to deal with all the material collected by the Provinces.

No Conferences were held during the year. The recommendations of the Silvicultural and Utilization Conferences of last year were held up for consideration by the Board of Forestry. That body has not met since, and as its next meeting is doubtful the recommendations have been taken up and are being dealt with by the Government of India.

CHAPTER II.

SILVICULTURE AND WORKING PLANS.

CENTRAL INSTITUTE.

I.—*Experimental Silviculture.*

General.—Under the division of labour as defined by the Silvicultural Conference in 1922, most of the work in general experimental silviculture is done locally in the provinces. The handing over of all the experimental plots is not yet complete, but there is this year nothing to report under the head except in the matter of the most suitable method of working bamboos. Results to date were published in the Indian Forester in November 1922 in an article entitled "Methods of Working Bamboos".

Otherwise the only work done under the head is the general collection of all available data on the ledger files. A very large amount of material is now collected, and will furnish much valuable information when staff is available to sort and write it up. At present it is out of the question to do this.

It was unanimously decided at the Silvicultural Conference of 1922 that copies of all experimental files opened by local Silviculturists should be sent to this Institute, and that a precis of observations made should be sent in yearly for entry. Only in this way could the Central Institute supply the information for which it is continually asked.

So far no files have come in from the provinces, but as the year has just ended it is expected that they will soon arrive.

Natural Regeneration.—A clear-felling experiment in Thano forest was commenced in March 1919 to see if in a really frosty locality it was possible to regenerate a sal forest in which established seedlings existed by the "Gorakhpur Method". It was divided into two sub-plots one cleaned and the other uncleaned. Plenty of shoots of sal appeared, but there was some damage by browsing.

in 1920. In the cold weather of 1920-21 practically all shoots were killed to the ground by frost in both the cleaned and uncleaned area. Browsing by deer was very bad in 1921, and the area was fenced in the hot weather of 1922. Frost damage was again very bad in 1921-22 cold weather in both sub-plots. In the cold weather of 1922-23 there was naturally little damage by browsing but frost again did very great damage. Practically speaking in the cleaned plot sal was again killed to the ground except near the shelter of a fig tree where some of the sal are 6 feet or more in height. In the uncleaned area also frost damage has done much harm, and only where *rohni Mallotus philippinensis* coppice has sheltered the sal has it suffered less. What will eventually happen cannot be foretold but it certainly appears at present that in such an area clear felling is unsuitable and a shelterwood is essential. Near by where a shelterwood had been left, though the process was slow, the sal has survived and grown. Eventually that on the clear-felled area may go through too, but up to date it has not.

Seeds.—Lack of staff and money has made it impossible to take up this important part of the work adequately during the year. This is essentially the work of the Central Institute, but it is a large question of itself and to attempt to undertake it at present would mean that it would not be done properly and erroneous conclusions would be the result. What few results are reported under this head have been incidental to other work. The following corrections and additions have been made in the "Note on Weights of Seeds"—Forest Bulletin No. 41.

Species.	No. of seeds.		No. of weighments.	Remarks.
	Per oz.	Per * ch.		
<i>Acacia decurrens</i>	2,150	4,300	1	
<i>Acacia Campbellii</i>	900	1,800	2	Single dry.
<i>Albizia odoratissima</i>	600	1,200	2	Dry seeds.
<i>Cinnamomum Camphora</i>	130	260	7	Fresh seeds without pulp.
Ditto	80	160	1	Fresh seeds with pulp.
<i>Cupressus torulosa</i>	6,800	13,600	4	
<i>Dalbergia Sissoo</i>	500	1,000	7	Pods.
Ditto	1,500	3,000	1	Seeds without pods.
<i>Entonia Plumeria</i>	400	800	1	Dry seeds.
<i>Ficus infectoria</i>	350	700	1	

Species.	No. of SEEDS.		No of weighments.	REMARKS.
	Per oz.	Per oh.		
<i>Grewia tiliaefolia</i>	570	1,140	1	
<i>Piptadenia oudhensis</i>	880	1,760	1	
<i>Quercus lanuginosa</i>	70	140	1	
<i>Sapindus emarginatus</i>	65	130	1	
<i>Suietenia Mahagoni</i>	100	200	1	
<i>Vateria indica</i>	2	4	1	

— The following plant per cents were observed during the year in connection with various experiments, though no special work was done on this point for reason of staff. These are additional to those published in last year's report. In the matter of plant per cents, in ordinary work of this sort where the point is not being specially tested, it must be remembered that the figure does not always represent the appearance of a bed. Thus in the case of *Bombax malabaricum* the figure for plant per cent. is actually 30 but the bed was literally full of plants. With small light seed, if 30 per cent. of the seeds produce plants, it is excellent, even 10 per cent. with very small seeds may be an excellent result. It may be noted that in 1922 the rains broke exceptionally late in Dehra Dun, which doubtless affected results.

Species.	Germination. per cent.	Plant. per cent.	Time to germinate.	REMARKS.
<i>Cinnamomum Camphora</i> (local)	Not tested	50	3 to 4 months.	Sown in November. Pulp removed.
<i>Cinnamomum Camphora</i> <i>Floriola.</i>	Not tested	66	1 to 3 months.	Sown 5th January. Pulp removed.
<i>Dalbergia latifolia</i>	Not tested	Very good.	1 to 4 weeks.	Sown 2nd June.
<i>Terminalia bellerica</i>	Not tested	51	4 to 8 weeks.	Sown 12th May. Seed soaked in cold water for 4 days before sowing.

There is a large amount of money involved in this seed work for those provinces where much artificial work is done. If by experiments here an increase of only 10 per cent. in germination could be produced or, with seeds which have to be stored, a saving

of deterioration of 30 to 40 per cent. could be got—quite possible figures—it would mean that amount of saving on all costs of collection, transport, size of nurseries, etc., etc., in connection with seedling work.

Nursery Work.—Nothing special to report. Most of the work done is reported under the next head.

Artificial Regeneration.—As was mentioned in last year's report a series of transplanting experiments have been started with four variations for each species,

- rains entire transplants,
- rains rooted cuttings (or root and shoot pruned transplants)
- winter entire transplant
- winter rooted cuttings.

Under each main experiment there were weeded and unweeded areas. Work was started on those species of which plants happened to be available. In most cases, as the first plants were only put out at the beginning of last rains and have therefore not yet survived one hot weather, it is too early to draw any conclusions. The results, however, are as follows :—

Acacia arabica—

Entire transplants.—Transplanted July 1922 : plants 3" to 32" high (6 months from seed) and roots 3" to 18" long.

Weeded 77 per cent. alive in March 1923 ; plants 6" to 3' 3" high.

Unweeded 47 per cent. alive in March 1923 ; plants 6" to 2' 10" high.

Rooted cuttings.—Transplanted July 1922. Stems cut down to 3", root 6". Plants 1 year old.

Weeded 28 per cent. alive by March 1923. Plants 3" to 7" high.

Unweeded None alive by March 1923.

Entire transplants.—Transplanted November, 1922.

Weeded plants 18 months from seed 62 per cent. alive in March 1923 plants 1" to 5".

Unweeded plants 2 months from seed 68 per cent. alive in March 1923 plants 1" to 5".

Rooted cuttings.—Transplanted November 1922. Stems cut down to 2" to 4" roots to 6". Plants 18 months old.

Weeded None alive by March 1923.

Unweeded None alive by March 1923.

Acacia Catechu—

Rooted cuttings.—Transplanted August 1922. Stems cut down to 3" and roots to 6". Plants 15 months old.

Weeded 40 per cent. alive by March 1923. Plants 4" to 6" high
Unweeded None alive.

Albizzia odoratissima—

Entire transplants.—Transplanted July 1922 ; plants 3" to 8" high and roots 5" to 9" long. About 3 months old.

Weeded 68 per cent. alive by March 1923 ; plants 2" to 2' high.

Unweeded 61 per cent. alive by March 1923 ; plants 5" to 3' high. These unweeded plants though actually as large as the weeded do not look at all healthy and will probably be choked out this rains.

Rooted cuttings.—Transplanted July 1922. Stems cut down to 3" roots 6". Plants 14 months old.

Weeded 96 per cent. alive by March 1923. Plants 4" to 15" high. Very healthy-looking at present.

Unweeded 80 per cent. alive by March 1923. Plants 4" to 14" high.

Entire transplants.—Transplanted November 1922 about 7 months old.

Weeded 62 per cent. alive by March 1923 ; plants 1" to 2" high.

Unweeded 42 per cent. alive by March 1923 ; plants 1" to 2" high.

Rooted cuttings.—Transplanted November 1922. Stems cut down 2" to 4" and roots 4" to 6". Plants about 7 months old.

Weeded 48 per cent. alive by March 1923. Plants 3" high.

Unweeded 28 per cent. alive by March 1923. Plants 3" high.

Bombax malabaricum—

Entire transplants.—Transplanted July 1922. Stems 4" to 9" high, roots 8" to 16". Plants 1 year old.

Weeded 64 per cent. alive in March 1923. Plants 2" to 9" high.

Unweeded 48 per cent. alive in March 1923. Plants 3" to 12" high.

Entire transplants.—Transplanted November 1921. Plants 6 months old. Height from 3" to 11", roots 4" to 12".

Weeded 42 per cent. alive by March 1923 ; plants 6" to 14" high.

Unweeded 20 per cent. alive by March 1923 ; plants 6" to 18" high.

Buchanania latifolia—

Entire transplants.—Transplanted August 1922. Plants 15 months old. Stems 12" to 3", roots 8" to 13".

Weeded 20 per cent. alive in March 1923. Plants 2" to 4" high.

Unweeded None alive in March 1923.

Rooted cuttings.—Transplanted August 1922 ; plants 15 months old ; stems cut down to 3", roots to 6".

Weeded 2 per cent. alive in March 1923. An absolute failure.

Unweeded None alive in March 1923. An absolute failure.

Entire transplants.—Transplanted November 1921. Plants 6 months old. Stems 2" to 4", roots 1 foot to 2 feet.

Weeded 4 per cent. alive in March 1923.

Unweeded None alive in March 1923.

August is late for rains transplants.

Cinnamomum Camphora—

Entire transplants.—Transplanted July 1921. Plants 20 months old.. Plants 9" to 4½' high and roots 10" to 18".

Weeded 62 per cent. alive in March 1923, and of the failures most occur in one spot. Probably can count on 80 per cent. Plants average 3' 6" to 4' high.

Unweeded 6 per cent. alive in March 1923.

Entire transplants.—Transplanted July 1922. Plants 6 months old. Stems 3" to 10" high and roots 6" to 9".

Weeded 90 per cent. alive in March 1923. Plants 2" to 12" high. Perfectly healthy.

Unweeded 26 per cent. alive in March 1923. Plants 3" to 19" high. Probably all will disappear this next rains.

Entire transplants.—Transplanted July 1922. Plants 6 months old. Stem 3" to 12" high and roots 6" to 11". Florida seed.

Weeded 88 per cent. alive in March 1923. Plants 2" to 15" high. All healthy.

Unweeded 48 per cent. alive in March 1923. Plants 3" to 12" high. These will probably disappear this rains.

Rooted cuttings.—Transplanted July 1921. Stems cut to 6" and roots 10". Plants 18 months old.

Weeded 70 per cent. alive in March 1923. Average high 2' 6" to 3'.

Unweeded 16 per cent. alive in March 1923.

Rooted cuttings.—Transplanted November 1921. Plants 2 years old. Stems cut to 4" to 6", and roots 9".

Weeded 40 per cent. alive in March 1923 and plants 2" to 9" high.

Unweeded None alive in March 1923.

Rooted cuttings.—Transplanted November 1922. Plants 1 year old. Stems cut to 2" 4" and roots 4" 6".

Weeded 86 per cent. alive in March 1923. Plants 3" high.

Unweeded 20 per cent. alive in March 1923. Plants 3" high.

Dalbergia latifolia—

Entire transplants.—Transplanted July 1922. Plants about 5 weeks old. Stems 3" to 5", roots 4" to 7".

Weeded 82 per cent. alive in March 1923 ; plants 5" to 14" high. Looking rather unhealthy.

Unweeded 18 per cent. alive in March 1923 ; plants 5" to 15" high.

Eugenia operculata—

Rooted cuttings.—Transplanted November 1922. Plants 27 months old. Stems cut down 2" to 4", roots 4" to 6".

Weeded None alive by March 1923.

Unweeded None alive by March 1923.

Gmelina arborea—

Rooted cuttings.—Transplanted July 1922. Plants 1 year old. Stems cut down to 3" to 6".

Weeded 94 per cent. alive in March 1923. Very healthy 7" to 25" high.

Unweeded 60 per cent. alive in March 1923. Plants 10" to 24" high.

Melia indica—

Rooted cuttings.—Transplanted August 1922. Plants 1 year old. Stems cut down to 3". roots to 6".

Weeded 52 per cent. alive by March 1923 plants up to 3" high.

Unweeded None alive by March 1923.

Prosopis spicigera—

Rooted cuttings.—Transplanted July 1922. Plants 14 months old. Stems cut down to 3". roots to 6".

Weeded 4 per cent. alive by March 1923.

Unweeded None alive by March 1923.

Rooted cuttings.—Transplanted November 1922. Plants 18 months old. Stems cut down to 2"-4" and roots 4"-6".

Weeded None alive by March 1923.

Unweeded None alive by March 1923.

Sapindus delcogens—

Rooted cuttings.—Transplanted August 1922. Plants 15 months old. Stems cut down to 3" and roots to 6".

Weeded 40 per cent. alive by March 1923. These look very healthy. Plants 5" to 11" high.

Unweeded 42 per cent. alive by March 1923. Plants 4" to 7" high.

Ternstroemia bayerica—

Entire transplants.—Transplanted July 1922. Plants 1 year old. Stems 1" to 9", roots 4" to 11".

Weeded 92 per cent. alive by March 1923. Plants 4" to 13" high.

Unweeded 42 per cent. alive by March 1923. Plants 4" to 8" high.

Rooted cuttings.—Transplanted July 1922. Plants one year old. Stems cut down to 3" and roots to 6".

Weeded 89 per cent. alive by March 1923. Plants 6" to 11" high.

Unweeded 82 per cent. alive by March 1923. Plants 6" to 16" high.

The following tabular statement summarises the above results—

Species.	Time and method of transplanting.	SURVIVAL IN MARCH 1923.		REMARKS.
		Weeded.	Un-weeded.	
<i>Acacia arabica</i> ..	Rains entire 1922 ..	77	47	
	Rains rooted cuttings 1922	28	NH	
	Winter entire 1922 ..	62	68	
	Winter rooted cuttings 1922	NH	NH	
<i>Acacia Catechu</i> ..	Rains rooted cuttings ..	40	NH	Done in August which is late.
<i>Albizia odoratissima</i> ..	Rains entire 1922 ..	68	64	The unweeded plants look unhealthy.
	Rains rooted cuttings 1922	90	80	
	Winter entire 1922 ..	62	42	
	Winter rooted cuttings 1922	48	28	
<i>Bombax malabaricum</i> ..	Rains entire 1922 ..	64	48	
	Winter entire 1921 ..	42	20	
<i>Buchanania latifolia</i> ..	Rains entire 1922 ..	40	NH	Done in August which is late.
	Rains rooted cuttings 1922	2	NH	
	Winter entire 1921 ..	4	NH	
<i>Cinnamomum Camphora</i> (Local seed).	Rains entire 1921 ..	62	6	Plants 18 months old.
	Rains entire 1922 ..	60	20	Plants 6 months old.
	Rains rooted cuttings 1921	70	16	
	Winter rooted cuttings 1921	40	NH	
	Winter rooted cuttings 1922	86	20	
<i>Cinnamomum Camphora</i> (Ilorin seed).	Rains entire 1922 ..	88	48	
<i>Dallergia latifolia</i> ..	Rains entire 1922 ..	82	38	
<i>Eugenia operculata</i> ..	Winter rooted cuttings 1922	NH	NH	
<i>Onclina arborea</i> ..	Rains rooted cuttings 1922 ..	91	60	
<i>Melia indica</i> ..	Rains rooted cuttings 1922	62	NH	Done in August which is late.
<i>Prosopis spiciifera</i> ..	Rains rooted cuttings 1922	4	NH	
	Winter rooted cuttings 1922	NH	NH	
<i>Sapindus detergens</i> ..	Rains rooted cuttings 1922	40	42	Done in August which is late.
<i>Terminalia beleich</i> ..	Rains rooted cuttings 1922	80	82	

Conclusions.—It is obviously too early to draw any definite conclusions in the case of most of these species. The whole series of variations are not yet complete. Any rains transplants, of 1922 have only faced one season's weed competition, if unweeded; and have not yet faced a hot weather. Therefore the end of the 1923 rains will be the first time that anything reliable can be said of them, for it is in the second year that weeds usually become most harmful, and also the hot weather is a season of heavy mortality. Still even the first rains indicates the relative advantages of weeding and non-weeding, though it seldom proves whether weeding is absolutely essential.

Still less can any real conclusion be drawn with winter plantings done in 1922, for they have as yet had practically no weed competition to face, if unweeded, nor have they faced a hot weather.

Weeding versus non-weeding.—Looking at the weeded and unweeded figures it is quite obvious that with practically every species the advantages of weeding are already apparent and in almost every case it is apparent that the percentage of failure even in the first rains is such that it is not worth while attempting transplanting without weeding and this applies both to rains planting and winter planting whether entire plants or rooted cuttings are used. The only apparent exceptions are winter entire transplants of *Acacia arabica*, easily explained as they have not yet had to compete with weeds; rains transplants of *Albizzia odoratissima* whether entire or rooted cuttings, and rains rooted cuttings of *Gmelina arborea* and *Terminalia belerica*. But it is highly probable that this time next year the unweeded areas of these will also be complete failure, for many look very sickly at present except perhaps *Gmelina arborea*.

Rains versus winter transplanting.—In the case of practically every species tested it is apparent even after the first six months that rains transplanting is very definitely preferable, whether entire plants are used or rooted cuttings. In most cases one can go further and say that winter transplanting is not sufficiently successful to be worth doing, but to this there are exceptions. *Acacia arabica* and *Albizzia odoratissima* show good success at present with winter entire transplants, and *Albizzia odoratissima*, *Bombax malabaricum* and *Cinnamomum Camphora* show a fair success with the winter rooted cuttings, but it must be remembered that they have not yet passed through one hot weather, and that is the time mortality will occur. Note how the survivals in the camphor have dropped in the plants put out in 1921 and which have therefore been through one hot weather.

Entire transplants versus rooted cuttings.—It is too early and the variations are not yet complete enough to make any general statements about this. It seems that in the following cases rooted cuttings do not give sufficient success to be worth doing; *Acacia arabica*, *Buchanania latifolia*, *Prosopis spicijera*. In the following

cases they seem at present as successful, or practically as successful, as entire transplants; *Albizia odoratissima*, *Cinnamomum Camphora*, *Gmelina arborea*, *Melia indica*, *Terminalia belerica*; but it must be remembered that they have not yet faced a hot weather and that it is the first hot weather when rooted cuttings are so liable to die. *Buchanania latifolia* seems a difficult species to transplant in any way, though August was late for transplanting and it may do better if done early in July.

Dendrocalamus strictus.—The following experiments were begun with seeds from Ranipur. All were weeded.

Mounds.—Sowings in July 1921. Plant per cent about 30 after a fortnight. They have slowly petered out and now are all dead. Unfortunately Mr. Howard was on leave when the mortality occurred, and he cannot therefore state definitely the cause. It was probably the abnormal drought in 1922.

Patches.—Sowings July 1921. Plant per cent. about 30. Only 7 seedlings survive ranging from 6" to 20". Please see remarks above.

Line sowing.—Sowings July 1921. Plant per cent. about 48 and now of the 48 per cent. one half survive and are all sizes up to 5'. Please see remarks above. Mr. Howard imagines the better survival and progress is due to the fact that it is easier to soil work and clean lines than patches, and the loose soil meant better root development and less mortality from drought.

Offsets 3 feet long from 1 year old culms planted vertically July 1921.
All struck and 100 per cent. are alive and have new culms up to 24 feet long.

Offsets 3 feet long from 2 years old culms planted vertically July 1921.
All struck and 100 per cent. are alive and have new culms up to 24 feet long.

Stem cuttings.—3 nodes length from 1 year old culms planted vertically July 1921.

A few sent out whippy shoots but all were dead within a year.

Stem cuttings.—3 nodes length from 2 years old culms planted vertically July 1921.

A few sent out whippy shoots but all were dead within a year.

Stem cuttings.—3 nodes length from 1 year old culms planted horizontally July 1921.

A few sent out whippy shoots but all were dead within a year.

Stem cuttings.—3 nodes length from 2 years old culms planted horizontally July 1921.

None ever struck at all.

Stem cuttings.—3 nodes length from 1 year old culm, notched and planted horizontally July 1921.

None ever struck.

Stem cuttings.—3 nodes length from 2 years old culms notched and planted horizontally July 1921.

A few sent out whippy shoots but all died.

Conclusions.—Stem cuttings are useless however done. Offsets with a portion of rhizôme attached and a good bud strike with ease and certainty, and survive and grow vigorously, whether from 1 year old or 2 years old culms.

The Silviculturist is not satisfied with the sowings. It certainly appears from this that under similar conditions the offset method is superior to sowings but the years were undoubtedly abnormal and in a normal year this might be very different. Sowings as a general rule are successful if weeded. It certainly appears, as conditions were similar, that line sowings are better than mounds or patches, though mounds might naturally be better in areas liable to inundation.

Reclamation and Afforestation.—Experiments have been going on for some years in Zabarkhet in order to determine a method of afforesting grassy blanks in sal forests. The area contains rank grass up to 8' and 10' in the rains, and is a bad frost hole.

It would have been comparatively simple to afforest the area with any frost-hardy species if weeding during the rains had been allowed; but the United Provinces, to whom this particular work specially applied, stated definitely that they could not accept a solution which involved rains weeding, the real problem being to afforest places where no labour was available in the rains.

In 1919 experiments over large areas were commenced in which no rains weeding was permitted, and the area now under various species and methods is some 8½ acres. So far as has been ascertained the only species experimented with which are worth considering for this purpose are *Dalbergia Sissoo* and *Pinus longifolia* both of which withstand frost and can be raised with no weeding in the rains.

Dalbergia Sissoo.

Sowings.—It is quite useless in heavy grass so far as appears at present to attempt to raise this species by sowings without rains weeding. With rains weeding it is perfectly simple by the usual methods of sowing. An experiment has even been made of ploughing the land, cleaning out all grass roots, and then sowing sissoo. Although the plants came up so thick that they were like a field of wheat, although they were 6" to 1' high at the end of the first rains, although what grass there was was cut in the first cold weather, although the second rains the area was still full of sissoo apparently exceedingly healthy, although the grass was again cut the second winter, the area now, at the beginning of the third growing season, contains only some weedy looking sissoo not much higher than they were at the end of the first rains, and which will undoubtedly peter out. It is true that with repeated sowings and

a great deal of luck an unweeded sissoo sowing may get through, but it is so much a matter of chance, and even then so patchy, that as a practical method of grass-land afforestation it may be ruled out unless weeded in the rains. It is moreover simply grass competition which has killed these plants, neither the frost nor damage by animals has had any appreciable effect.

Transplanting whole plants.—The experiments tried with unweeded transplants have not been a great success. It is possible they would succeed but the next method is so much easier and more certain that it is better to adopt it.

Transplanting root and shoot pruned transplants.—Sissoo are raised in a nursery and then planted out when about the thickness of one's thumb by cutting down the stem to 2" or 3" length and the root to 9" to 1 foot taking care that the earth after transplanting comes up to the collar. The actual best length is not yet known, but that length is quite adequate. The planting holes should be prepared sometimes beforehand, and the bigger they are the better, but about 9" diameter and 1 foot to 18" deep is sufficient. The dangers these sissoo cuttings will have to face are grass competition, drought in the hot weather, frost, uprooting by pigs and grazing by wild animals.

Light frost will hardly affect the plants, heavier frosts will kill the plants for some inches from the top, and an exceptional frost will kill the plants to the ground but they will spring up again. This rather rules out sissoo in a bad frost area and, though it is fairly frost hardy, *chir* is certainly preferable to it in such places. Grass competition need not be feared. It is preferable to cut the grass in the rains if it is practicable, and in the cold weather if it cannot be done in the rains; but in most grass areas it is not essential. Drought in the hot weather is a danger and will be referred to more particularly under the next heads. When these root and shoot cuttings sprout they first send out leaves from the material stored in the planted "stick", and then manufacture roots. If sufficient roots have not been produced by the hot weather the plants will die; and it has not been ascertained exactly how much root is necessary for the plants to survive, in any case it depends on the locality.

Damage by pigs and deer will be referred to later. In all root and shoot-cuttings nursery plants are preferable to those dug up from neighbouring forest; and although success has been obtained here with such forest plants it has not been a sufficient success. This is probably largely due to exposure of the root and shoot-cuttings to the sun. A few hours exposure to hot sun will cause a lot of failures and must be avoided.

Winter transplants of root and shoot-cuttings.—The object of this was to avoid grass competition. By cutting all grass in October or November, burning what was left and then putting out the transplants at the end of November or early in December it was

hoped the new plants would be 3 feet high by the beginning of the rains and thus get away above the grass from the start, as the grass does not really commence to compete till the rains. The method however is probably not worth doing. It is perfectly true that if everything goes well it does succeed best of all, but it is unlikely that everything will go well. If there are no winter rains the plants will not sprout till late, and there will be a large percentage of failures the first year. Sometime only some 20 per cent. will succeed. If there are winter rains but no hot weather storms sprouting will begin in March and go on vigorously ; but root development will be insufficient and there will be a large amount of failure in the hot weather. Forty or more per cent. failure may result. If there are winter rains and regular hot weather storms then 90 per cent. may succeed and will be 3 feet high before a rains transplant had commenced ; but on the whole it is too much of a gamble on the weather and the next method is sufficiently certain.

Rains transplants of root and shoot-cuttings.—This is exactly the same as before but the plants are put out when the rains break. They should be 3 feet high by the end of the rains, with good roots sufficient to carry them over the next hot weather. Whether grass is cut in the cold weather or not will depend on local circumstances. It is better to cut it but, unless it is heavier than at Zabarkhet, not absolutely essential. The rate of growth will vary largely with locality. The plants may be 3 feet high the first year and 6 feet the second ; but in Zabarkhet we have not managed this. They get 3 feet high the first year, but they then have rather a struggle and so far they are not yet really above the grass anywhere. Sometimes too they will only get up a foot the first rains, and that means a further struggle with the grass. The plants are undoubtedly being kept back by the frost. Sometimes they are killed to the ground more often they are killed a foot or more and though they will probably go through eventually they are at present much the same size as they were the first year.

Pinus longifolia.—This is the most successful species tried. The dangers it has to face are the same as for the sissoo but it seems quite unaffected by the frost and really only fears drought in the hot weather : so much so that it actually seems to prefer being unweeded, which is exactly what is wanted. It is absolutely necessary to red-lead the seeds before sowing, or all will be eaten. An area here was tried by ploughing the land and cleaning out all grass roots, sowing the *chir* in lines on the ploughed land early in July, and no subsequent tending. This procedure is unnecessary and expensive and gives results no better than the line method. In the line method lines about 9" wide were either ploughed through the grass or carefully hoed up. Hoing is better but ploughing is good enough if the clods are broken up. Grass root should be removed. The seeds should be red-leaded and sown thick 3" or 4" apart when the rains have broken, here about July 1st. The *chir* will germinate in about 10 days or a fortnight and no weeding or cleaning.

is necessary. The grass should not be cut the next year, and when the young *chir* are a year old they will be 3" to 4" high. There will be mortality from drought the first hot weather and it may be necessary to resow, although it has been unnecessary in Zabarkhet. At the end of that rains the seedlings will be about 1 foot high. A certain amount of judgment about grass cutting is now necessary. It is not necessary, but it may be beneficial to cut the grass *between* the lines to prevent it falling over and crushing the young *chir*; but it depends on the size and healthiness of the plants. By the time they are 2 years old they will be about 18" high. During the next cold weather grass-cutting between the lines is certainly advisable and probably now necessary. When it is cut the *chir*, which will often be very lanky and twisted in their efforts to reach light from under the grass, may not have enough strength to stand up, but this does not matter—they will straighten later. The third year the best plants will be 3 feet high and should then go straight through.

Animals.—Pigs are the worst. They root up a great many *sissoo* but *chir* area they will wipe out completely. Unfortunately the amount of damage they did was not realised till this year, and there is no question that more of the failures in the *chir* here are due to pig than anything else. A pig will go down a line and root up every plant in a night. The area has now been fenced, and fencing is absolutely essential to success if there are pigs about. Deer also browse both *sissoo* and *chir*, *sissoo* far more than *chir*; but though for this cause alone fencing *may* not always be absolutely necessary it is certainly advisable.

Thinnings and cleanings.—Nothing special to report. So far it has been assumed that thinnings are beneficial and sample plots are all thinned for the quick production of yield tables. Once these have been issued comparative research into different intensities of thinnings will be started. A few such plots are already in existence but up to date have not progressed far enough to report.

Mixtures.—Nothing to report.

Underplanting.—Nothing to report. The plot of *Pinus longifolia* underplanted with *Quercus incana* still exists.

Silvicultural systems.—Nothing to report.

Working Plans and Statistics.

Working Plans.—The following working plans have been received during the year.

1. Working Plan of Sal Forests, Kamrup Division, Western Circle, Assam. 1919-1929.
2. Working Plan of the Thana Forests, Bombay.
3. Working Plan for the North Garhwal Forest Division, United Provinces for 1921-22 to 1930-31.

4. Working Plan for bamboos and minor forest produce in the South Vellore Division, Madras.
5. Working Plan for the forests of Sironeha Range, South Chanda Forest Division, Central Provinces.
6. Revised Working Plan of the Yillapur and Mundgod Teak high forests, Kanara, Bombay.
7. Working Plan for the Sambalpur Forest Division, Behar and Orissa.

The small scheme for providing an educational forest at the new Research Institute has unfortunately not been commenced owing to want of staff and money. It is a pity, as forests can not be grown all at once ; and it would have been better to have got this particular work in hand some years before the inauguration of the expanded educational scheme.

Yield Tables.—The Central Institute has measured 35 sample plots during the year. A great deal more would have been done if the Punjab tour in the deodar areas had not been cancelled owing to the inability of the local authorities to provide transport. The cancelling of this tour is to be regretted, as the statistics for a deodar yield table lack certain data which could have been collected, and which would have made the publication of a deodar yield table possible. Now this publication is held up indefinitely. On the other hand this field measuring on the part of the Central Institute is not altogether desirable owing to this very difficulty, namely the transporting of a large staff over long distances in various localities. The local Silviculturists are rapidly expanding in this direction, with the result that the work of compiling and working up their results has increased to such proportions that the present staff is entirely inadequate to cope with it. Since Mr. Howard's return from leave in October last, 125 sample plots and 7 experimental plots have been worked up ; but there are unfortunately a very large number still in arrear and more are coming in daily.

More would have been done but it was considered that the available staff and time could be more usefully spent in compiling the results already obtained into a Sal Yield Table, which was urgently required for the United Provinces. There were so many working plans actually in course of revision in the United Provinces that it was felt that the production of a yield table was a matter of absolute and immediate necessity. The yield table is now in the press ; and beside the actual yield table, etc., the publication contains various silvicultural matters. It is a joint production of the United Provinces, and the Central Silviculturists. The silvicultural work is the work of the United Provinces, the measurement of the plots has been done principally by the Central Institute, and the compilation of the results into yield table—in fact the statistical part—has been done by the Central Silviculturist with certain help in the matter of thinnings, etc., by the United Provinces. A copy of the table is appended and it may be useful.

It must be pointed out that strictly it applies only to the United Provinces, though it may help other provinces.

A general yield table of sal for India will be undertaken directly more staff is appointed. The data already exist or will arrive shortly.

It is hoped that the few data necessary for the publication of a *chir* yield table will be available this hot weather and that a table will be issued in the coming year.

Volume and Form Factor Tables.—No new volume and form factor tables have been compiled during the year. The re-issue of the sal volume table foreshadowed in last year's report has not been undertaken, as there has been insufficient staff to cope with it. Every type tree felled however for whatever purpose is entered up in the records, and data are now available to issue complete tables, and it is hoped these will be published in the near future.

Data are available for the issue of preliminary tables for other species but again lack of staff is causing serious delay in compilation.

Bark measurements, heartwood measurements, etc.—These data obtained from many type trees measured are entered up as usual and will form part of the volume and form-factor tables when issued.

Miscellaneous.—The staff have made tours during the year in Bengal, the Punjab, Bihar and Orissa and the United Provinces. More touring would have been done if there had been more funds; and if the local authorities could have provided transport a much longer tour would have been made in the Punjab.

The photographic collection now contains some 3837 prints, 4237 negatives, 538 lantern slides, 6 colour positives and 4 cinema films. A new catalogue has been prepared (and it is hoped will be printed). The increase over last year is not large, but does not in any way represent the work done. A large amount of copying work has been done for the London Exhibition, replacing perished negatives, etc., etc., and in many cases where there is only an addition of one print to the collection several copies have been printed for various departments. The photographic work is however, on an entirely unsatisfactory basis and it is hoped it will be improved in the near future.

Yield for one

Age.	MAIN CROP.									THINNING.		
	Average diameter.	Average height.	Total basal area.	Number of trees.	Stem timber form factor.	Small wood form factor, stem and branch.	Standing volume stem timber.	Standing volume small wood.	Total standing volume stem timber and small wood.	Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.
	In.	Ft.	Sq. ft.				C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.
20	6.0	51	85	433	0	417	0	1,810	1,810	0	1,120	1,120
30	8.7	67	107	257	140	283	1,000	2,030	3,030	0	820	820
40	11.2	79	123	180	210	187	2,330	1,820	1,150	230	590	820
50	13.3	90	132	137	284	127	3,370	1,510	4,880	360	410	770
60	15.2	98	136	108	309	009	1,120	1,320	5,440	410	280	690
70	16.8	106	137.5	89	325	085	4,710	1,210	5,980	435	210	645
80	18.5	111.5	138.5	74	335	080	5,170	1,235	6,405	450	160	610
90	20.1	116.5	139	63	340	081	5,500	1,310	6,810	450	130	580
100	21.6	120	139.5	55	344	085	5,750	1,420	7,170	450	115	565

acre of *Sal*—I Quality.

FINAL YIELD.			ACCUMULATED YIELD OF THINNINGS.			TOTAL YIELD.			CURRENT ANNUAL INCREMENT.		MEAN ANNUAL INCREMENT.	
Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.	Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.	Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.	Stem timber.	Total stem timber plus small wood.	Stem timber.	Total timber plus small wood.
C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.
0	2,030	2,030	0	1,120	1,120	..	2,030	2,030	NH	201	..	146.5
1,000	2,850	3,850	0	1,040	1,040	1,000	3,070	4,070			33.3	165
2,560	2,410	4,970	230	2,630	2,760	2,560	4,350	6,010	130	194	64.0	172.7
3,730	1,920	5,650	590	2,040	3,530	3,960	4,450	8,410	140	160	70.2	168.2
4,530	1,600	6,130	1,000	3,220	4,220	5,120	4,540	9,660	110	125	85.3	161.0
5,175	1,450	6,625	1,435	3,430	4,865	6,175	4,670	10,845	105	116	88.2	154.9
5,620	1,395	7,015	1,885	3,590	5,475	7,055	4,825	11,880	88	103	88.2	148.6
5,950	1,440	7,390	2,335	3,720	6,055	7,835	5,300	12,865	78	98	87.1	142.9
6,200	1,535	7,735	2,785	3,835	6,620	8,535	5,255	13,790	70	93	85.4	137.9

Yield for one acre

Age.	MAIN CROP.									THINNING.		
	Average diameter.	Average height.	Total basal area.	Number of trees.	Stem timber form factor.	Small wood form factor. stem and branch.	Standing volume stem timber.	Standing volume small wood.	Total standing volume stem timber and small wood.	Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.
	In.	Ft.	Sq. ft.				C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.
20	4.2	40	77	780	0	316	0	970	970	0	600	600
30	6.4	53	87	300	0	383	0	1,765	1,765	0	600	600
40	8.7	63.5	104	252	157	266	1,040	1,760	2,800	0	600	600
50	10.8	72	116	181	230	183	1,920	1,570	3,490	140	420	500
60	12.6	80	123	145	260	139	2,560	1,370	3,930	220	315	545
70	14.0	87	126	116	282	116	3,090	1,270	4,360	200	230	540
80	15.4	92	127	98	297	106	3,470	1,240	4,710	315	200	515
90	16.8	96.5	127	82	305	103	3,740	1,325	5,065	320	150	470
100	18.1	100	127	71	310	113	3,940	1,435	5,375	325	135	460

of Sal—II Quality.

FIRM. YIELD.			ACCUMULATED YIELD OF THINNINGS.			TOTAL YIELD.			CURRENT ANNUAL INCREMENT.		MEAN ANNUAL INCREMENT.	
Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.	Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.	Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.	Stem timber.	Total stem timber plus small wood.	Stem timber.	Total stem timber plus small wood.
C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.
0	1,570	1,570	0	600	600	0	1,570	1,570	..	139	..	78.5
0	2,365	2,365	0	1,200	1,200	0	2,965	2,965	..	164	20	98.8
1,010	2,360	3,370	0	1,800	1,800	1,040	3,560	4,600	..	125	41.2	115.0
2,060	1,990	4,050	140	2,220	2,360	2,060	3,790	5,850	102	99	48.8	117.0
2,700	1,685	4,475	370	1,535	2,905	2,930	3,905	6,835	87	97	53.6	113.0
3,380	1,520	4,900	660	2,785	3,445	3,750	4,055	7,805	82	86	55.6	111.5
3,785	1,440	5,225	975	2,085	3,960	4,445	4,225	8,670	69.5	83	55.9	108.4
4,060	1,475	5,535	1,295	3,135	4,430	5,135	4,400	9,495	59	77	55.6	105.5
4,265	1,570	5,835	1,620	3,270	4,890	5,560	4,705	10,265	52.5			102.6

Yield of one acre

Age.	MAIN CROP.									THINNING.		
	Average diameter.	Average height.	Total basal area.	Number of trees.	Stem timber form factor.	Small wood form factor, stem and branch.	Standing volume stem timber.	Standing volume small wood.	Total standing volume stem timber and small wood.	Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.
	In.	Ft.	Sq. ft.				C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.
20	2.5	31	52	..	0	119	0	240	240	0	0	0
30	4.5	43	72	652	0	319	0	1,080	1,080	0	410	410
40	6.7	51	88	359	052	363	230	1,030	1,560	0	410	410
50	8.6	59	101	250	163	261	965	1,575	2,540	0	115	415
60	10.2	65	109	192	212	186	1,500	1,320	2,820	65	255	320
70	11.6	60	113	151	210	147	1,870	1,145	3,015	135	230	365
80	12.8	73	114	128	257	131	2,110	1,115	3,255	180	195	375
90	14.0	76	114	107	268	131	2,320	1,160	3,480	200	160	360
100	15.2	78	114	90	275	140	2,415	1,215	3,690	205	130	335

of *Sal*—III Quality.

FINAL YIELD.			ACCUMULATED YIELD OF THINNINGS.			TOTAL YIELD.			CURRENT ANNUAL INCREMENT.		MEAN ANNUAL INCREMENT.	
Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.	Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.	Stem timber.	Small wood, stem and branch.	Total stem timber and small wood.	Stem timber.	Total stem timber plus small wood.	Stem timber.	Total stem timber plus small wood.
C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.	C. ft.
0	240	240	0	0	0	0	240	240	..	128	0	12.0
0	1,520	1,520	0	440	440	0	1,520	1,520	23	122	0	50.7
230	2,070	2,300	0	880	880	230	2,510	2,740	74	112	10.3	68.5
905	2,020	2,985	0	1,325	1,325	905	2,900	3,865	60	60	20	77.3
1,565	1,575	3,140	65	1,580	1,645	1,565	2,000	4,465	50	50	20.6	74.4
2,005	1,375	3,380	200	1,810	2,010	2,070	2,955	5,025	45	61	31.5	71.4
2,320	1,310	3,630	380	2,005	2,385	2,520	3,120	5,640	38	58	32.2	70.5
2,520	1,320	3,840	580	2,165	2,745	2,900	3,325	6,225	33	54	32.3	60.2
2,650	1,375	4,025	785	2,295	3,080	3,230	3,510	6,770				67.7

ASSAM.

1.—*Experimental Silviculture.*

General.—It is very doubtful whether any method except clear-felling and artificial sowing or planting will be successful in reproducing the evergreen forests of Assam; with rare exceptions, all the more valuable species are strong light-demanders, and will bear little or no overhead shade; the only exceptions of importance are *hollong* (*Dipterocarpus pilosus*) and *amari* (*Amora spectabilis*).

Plantation work has been done in a number of divisions, both with and without field crops, and in most divisions it is to the former method that we must look for the reproduction of the forests but in some divisions it is difficult to find suitable cultivators to undertake the work; it is only where there is a shortage of land for temporary cultivation that applications are made to cultivate in reserves on condition of planting or sowing of useful species in lines between the crops.

Natural Regeneration.—Experiments were continued in the Sibsagar Division, the object being to find out the amount of tending required to ensure the natural reproduction of the principal evergreen species, the chief species tended being *Cedrus Deodars*, *Phoebe* sp., *Dunbanga sonneratioides*, *Amora spectabilis*, *Chikrassia tabularis*, *Artocarpus Chaplasha*, *Lagerstroemia Flor-Reginae*, and *Dipterocarpus pilosus*. The experiments are in too early a stage to show whether it will be possible to reproduce forests on a large scale in this way.

Seeds (germination percent).—The following experiment was made with teak seeds by the Divisional Forest Officer, Sylhet. Mr. B. C. Sen Gupta, after other methods had not been very successful:—

“Seeds are soaked in a fresh cow-dung emulsion in a kerosine tin and kept in the sun for 3 days. They are then spread in the bed of a shallow pit, say 10' × 5' and covered with dry thatch grass and sprinkled with water. The whole thing is covered with 2" of earth and kept moist by sprinkling water. A good number of seeds burst in seven days. All the seeds are removed and laid on the nursery bed and are covered with sand about 1" thick. They are watered profusely daily. The explanation of the above process is that the ammonium hydroxide in fresh cow-dung emulsion hastens the penetration of moisture, heaping in a tin and keeping the seeds in the sun help in generative heat; and heat, moisture, and air all combine when the seeds are kept in a shallow pit and are covered with grass and earth and watered. All the seeds cannot be expected to germinate at the same time, so they must be removed from the pit as soon as a good number of them have burst, else the germinated seeds will be spoilt. The best time in this Division is June, but it is better to force germination in April and May so that the seedlings may have a full growing season before them.

In Cachar Division, Mr. C. J. Rowbotham, Deputy Conservator of Forests, has experimented with the germination of seeds of *Morus laevigata* by soaking the seeds for 3 to 4 hours in dilute—hydrochloric acid. Good germination was obtained from the seeds thus soaked, while none of the seeds not soaked germinated. It is intended to try this year with seeds of *Cinnamomum glanduliferum* and *Michelia excelsa*, in both of which germination is very difficult.

Nursery Work.—Nurseries have been commenced in Cachar to study the germination and seedling growth of local species. Of the species tried, *Gmelina arborea*, *Lagerstroemia Flos-Reginae*, *Trewia nudiflora*, *Bombax malabaricum*, *Eugenia* sp., *Artocarpus Chaplasha*, and *Amoora spectabilis* germinated nearly cent per cent. In the case of *Cinnamomum glanduliferum* and *Michelia excelsa*, germination was a total failure, and experiments with hydrochloric acid, as mentioned in paragraph 7 will be tried: the seeds of these species appear to germinate in the forest only after being passed by birds, chiefly the imperial pigeon and the hill mynah. In Lakhimpur Division a nursery of 1½ acres was commenced of *Terminalia myriocarpa*, *Lagerstroemia Flos-Reginae*, *Cedrela Toona*, and *Bischofia javanica*. The last three named species germinated cent per cent., but of the *Terminalia* only 50 per cent. germinated.

Artificial Regeneration.—Experiments were continued or commenced in most divisions of the province for the purpose of investigating the most satisfactory methods of reproducing the forests artificially according to locality and species. The experiments were done under heavy shade, light-shade, and on clear-felled land; both direct sowing and planting out were tried, but no results can yet be recorded. Experiments in the introduction of teak *taungya* were commenced in Cachar and Sylhet.

II.—Working Plans and Statistics.

A commencement was made in the revision of the Working Plans of the Goalpara and Cachar Divisions. Sufficient measurements have not yet been made of each species to make the preparation of tables of form factors and volume yet possible, but the collection of measurements is continuing.

BENGAL.

1.—Experimental Silviculture.

General.—Silvicultural experiment in Bengal continues to be largely in the direction of *taungya* plantations, although, in places where this is impossible owing to lack of cultivators, considerable areas in several divisions have restocked themselves naturally after clear-felling, and this natural regeneration requires only a little attention to establish itself as a dense and often almost pure crop. Except in the Sunderbans, where it is satisfactory, natural regeneration can hardly be regarded as more than a last resort because

of its uncertainty ; and because, in most cases, the result is chiefly firewood species, or at best inferior box-planking trees. The notable exception is *Aerocarpus fraxinifolius* in the foot-hills, which has turned several *laungya* failures into successes, and is quite a good timber. Apparently neither natural nor artificial regeneration can be established on a scale worth considering in most of our Bengal forests except in clearings, as any lightening of the canopy is responded to far more quickly by evergreen undergrowth and creepers than by the tree species which it is desired to help.

Natural Regeneration.—Although, as noted in the last paragraph, natural regeneration (except in the Sundarbans) appears to be only possible in clear fellings, certain tree species seem to come up and thrive under heavy shade, and no doubt sometimes break through into the upper storey. It is very doubtful whether any assistance is possible to enable them to get through in sufficient numbers to be of any practical use. The most noticeable of such species are *Amoria Wallichii*, *Amoria Rokhituka* and the allied *Dysoxylum lincetiferum*, the valuable *Michelia Champaca*, and a leguminous tree *Pithecolobium angulatum*. It is noticeable that none of these species are common, and the last decidedly rare, in the upper storey of the existing forest ; a further indication that the composition of the crop is changing. None of these species come up naturally in clear fellings ; instead we get such light-demanders as (in the Duars and Terai) *Strombosia villosa*, *Garcinia pinnata* and *Callicarpa arborea* as coppice, and various species of *Macaranga* and *Mallotus*, *Trema orientalis* or *Sapium eugeniaefolium* as seedlings, one or other of these species coming up as an almost pure crop with a few *Anthocephalus Uadamba* and *Mangium bignonifolia*. In similar situations in the hills, at all elevations up to 6,000 ft., we get various species of *Macaranga* or *Mallotus* with *Evodia fraxinifolia* and *Erythrina arborescens* in the upper part ; and the *Macaranga* may be replaced by almost pure *Aerocarpus fraxinifolius* or *Evodia meliifolia* or *Sapium eugeniaefolium* in the foot-hills. The coppicing species in the hills between 4,000 and 6,000 ft., are chiefly *Eurya* and *Symplocos* spp.

Seed collection, etc.—There is nothing new to record under this head.

Nursery work.—There is very little that is new to report. The practice of pricking out *Eucalyptus* seedlings into baskets instead of into beds has increased our success with these species. In Chittagong some nursery experiments with the various *Dipterocarps* are in progress. On the whole the number of species which it is believed are better sown direct is on the increase.

Artificial regeneration.—Two experimental innovations are reported. The first is cold-weather planting of some species in the hills, notably *Alnus nepalensis*, which were formerly planted in the

rains only. Considerable success has been achieved in this direction in Darjeeling Division by the use of small nursery plants sown in February and planted out in the following December or January. Better results appear to be obtained besides the advantage of distributing the demand for labour and the better work which can be got out of the coolies in dry weather. The other innovation is an experiment on a large scale in the foot-hills in sowing thickly in lines 6 ft. apart both with and without cultivation instead of planting or sowing in *thalis*. A very large number of species have been sown in this way in practically all the foot-hill coupes of the Kalimpong Division. It is claimed that though the cost in seed collection is high, there is a saving in tending. The results will be watched with interest.

Reclamation and re-forestation. Nil.

Thinnings and cleanings.—There is little to report under this head; heavy and early thinnings have been made in young teak in Chittagong Hill Tracts and Kurseong Divisions in accordance with the latest ideas on this subject.

Mixtures.—There is nothing new to report. Several mixtures are being experimented with, but none can be said to be out of the experimental stage.

Under planting.—None has been tried, principally because, with the exception of sal most of our species keep themselves clean after two years and sal is so slow-growing that no subsidiary species has been found for it.

II.—Working Plans and Statistics.

Sample Plot Work.—In the Sunderbans Division four $\frac{1}{4}$ acre sample plots of *gewa* (*Excoecaria Agallocha*) have been laid out at varying distances from the sea, and one or two plots have been made in the slow-grown *sundri* (*Heritiera Fomes*), the so-called *Pakka Sundri*. In Chittagong Hill Tracts sample plots are now being laid out for the purpose of investigating the question of regeneration and rate of growth of the *Dipterocarps*. Ring-counting for sal has just been started.

BILAR AND ORISSA.

General.—Little progress in Forest Research work was possible during the year as the recently sanctioned post of Silviculturist, who in this province is responsible for both Silvicultural and Utilization research, was vacant during most of the year owing to the absence of the incumbent on leave; and Divisional Forest Officers had little spare time in which either to initiate or carry out research experiments. At the same time it is gratifying to be able to record that a definite start has been made in at least one of two directions. On his return from leave the Silviculturist visited the forests of Damoh Division in the Central Provinces with the object

of studying the methods of lac cultivation which are meeting with such great success in that division ; and at the close of the year he was engaged in drawing up proposals for the development of lac cultivation on a large scale in the Government forests of the Province.

The Imperial Silviculturist toured for three weeks in Singhbhum and Puri Divisions. As a result of his visit and advice it was decided to initiate certain experiments to decide the best methods of regenerating forests in which natural regeneration of sal or other species of value is deficient or absent. Further the Provincial Silviculturist was engaged on collecting information about the various forest problems requiring solution and it is the present intention to lay down a definite programme of research both in Silviculture and in Utilization which will be initiated early next year. If then we cannot claim as yet to have marched very far along the many roads of progress that stretch before us, it may at least be said that we have stepped a little way down some and made a preliminary survey of others.

I.—Experimental Silviculture.

General.—As in previous years research work on silvicultural problems was limited to experiments initiated by Divisional Forest Officers in their respective divisions.

Natural Regeneration.—The province is fortunate in that as a general rule the natural reproduction of its principal species sal is wonderfully good ; and few if any special measures are required to induce it. The sal forests of Puri division are an exception however, as long-continued fire protection has resulted in the complete disappearance of sal seedlings and poles over considerable areas, generally in the bottom of valleys and along the lower slopes of the hills, and their replacement by worthless evergreen species. To solve the problem of re-obtaining natural regeneration various experiments in opening up the canopy and burning the undergrowth have been initiated in recent years and are now in progress. The results up to date indicate :—

- (1) That excessive opening of the upper canopy results in a rapid growth of weeds, creepers, etc., but that although this cover is very dense it is not as harmful to sal seedlings as the cover afforded by the dense canopy of larger trees, whether sal or miscellaneous.
- (2) That under a high cover sal seedlings perish soon after germination, but under a low dense cover they can persist for years.
- (3) That where all miscellaneous species are felled and only sal seedbearers are left, regeneration is induced ; but if the sal overwood is dense and not heavily opened out the seedlings perish for want of light.

During the visit of the Imperial Silviculturist to the Puri forests in February the whole problem was carefully studied and as a result it was decided to initiate further experiments in thinning out or clear-felling the overwood and in burning the undergrowth for several years in succession. These experiments will be carried out under the control of the Provincial Silviculturist and they will be described in next year's report.

Seeds.—It has been found in Puri division that the burial of teak seeds for some months prior to sowing gives the best germination results; and that where time is insufficient for burial, watering the seeds daily in nursery beds covered with straw induces germination in about ten days time.

Nursery work.—In the Puri Casuarina plantations it has been definitely proved that plants raised in bottomless pots are much more successful than those transplanted without pots.

Artificial regeneration.—The teak *toila* plantations in Puri division were extended by 191 acres at no cost. The spacing has been reduced within recent years from 22' \times 16½' to 11'; but it is quite evident that even the latter spacing is much too wide and efforts are now being made to reduce it to 6' \times 6'. The *toila* cultivators object to such a reduced spacing; but probably it will prove sufficiently attractive to them if they are permitted to cultivate the soil for one year previous to the sowings being done. It has been found essential to get the teak seedlings successfully established during the first year as in after years subsequent sowings fail through lack of proper attention. The system of sowing teak in lines cut through the forest has now been definitely abandoned in favour of the *toila* system. It is true that teak sown in cleared lines suffer less from drought than under the *toila* system, but their growth is irregular and the stems are fluted and of poor quality. Regular growing space has been found essential.

In case failure should attend the experiments to obtain natural regeneration of sal it was decided on the advice of the Imperial Silviculturist to carry out next season experiments in artificially regenerating sal in hood-up lines on the system successfully followed in Bengal. It is to be feared that unless the sowings can be carried out in conjunction with the raising of field crops the cost will be excessive.

Reclamation and Afforestation.—The area of the Puri Casuarina plantations was extended by 869 acres at a cost of Rs. 8-6 per acre. The present spacing is 10½' \times 1½' but is considered that closer spacing may give better financial results, and it has therefore been decided to plant up experimental plots 4' \times 4', 6' \times 6', and

8' x 8'. The Puri Casuarina forests represent a splendidly successful effort at reclaiming barren sand dunes ; and there is little doubt that financially they will prove exceedingly profitable.

II.—Working Plans and Statistics.

Yields Tables.—No new sample plots were started. The sal sample plots established in Singhbhum division in 1918 by the Imperial Silviculturist were remeasured by him in February. These plots will now be taken over by the Provincial Silviculturist. As the data from the Singhbhum plots are being incorporated in the all-India yield table for sal under preparation by the Imperial Silviculturist it is hoped that the latter will be applicable to most of the sal forests of the province, and that there will be no necessity to lay down further vast numbers of plots to obtain data for a purely provincial table.

Volume and Form Factor Tables.—With a view to obtaining local volume tables for sal the Puri Divisional Forest Officer has commenced measuring up sal trees felled in the annual coupes. It is to be hoped that sufficient trees will have been measured next year to yield data for proper Volume Table.

BOMBAY.

No information available.

BURMA.

General.—Mr. H. R. Blanford has been in charge of the Silviculturist's office during the year. Unfortunately from the 5th September to the 7th December 1922 he had also to hold charge of the Northern Circle, and again from the 1st March he has had to take over the Illaing Circle in addition to his ordinary charge. This has seriously interfered with research work.

At the commencement of the year the Silviculturist was engaged in a tour in Katha Division. Experimental plots were laid out to study the regeneration of *in* (*Dipterocarpus tuberculatus*) in the *indaing* forests in the Yinke Reserve ; and the natural and artificial regeneration of *in* and *ingyin* (*Pentacme suavis*) was studied. A visit was then paid to the regeneration work in the Mohyin Working Circle, and an experimental nursery was started on Bengal lines. Experimental plots for the regeneration under varying conditions of cover for *in* (*Dipterocarpus tuberculatus*) and *Kamrin* (*Dipterocarpus tinbinatus*) were also laid out at Pinye and Naba. Late in April a visit was paid to the afforestation work in the Bhama Kachin Hills. Time was spent in Katha, where the experimental plots previously laid out were examined and a visit was paid to the regeneration work in Mar and Shwag Division, a note on the work with suggestions for the future being drawn up.

Towards the latter part of July Messrs. Shebheare and Glasson from Bengal and C. E. L. Gilbert from Bombay paid a visit to Burma in order to become acquainted with the Burma methods of regeneration in *taungyas*. Unfortunately the Silviculturist was unable to accompany them on their tour as he was laid up in hospital. Work was done in headquarters during August, September and October. In November a tour was made in Katha Division, when the experimental plots laid out in the previous April were visited and a number of permanent sample plots were laid out mainly in the teak regeneration in the Mohmyin Working Circle. During December sample plots were laid out in the Pyonehaung teak plantations in North Toungoo Division, and then in the Mohmit teak plantations in the Pyinnana Division. The whole of January was spent at Mohmit, and a very good series of sample plots was laid out in plantations of 6 years and over. The methods of carrying out thinnings in young teak plantations were also studied. During February a tour was made in Tharrawaddy Division, and a number of sample plots and experimental plots in the younger regeneration areas were laid out. It was intended to continue the tour through Zigon Division but unfortunately the Silviculturist was recalled to take over the Hlaing Circle at the end of February.

Office.—Considerable progress has been made in the organisation of the ledger files, and although a good deal of the available information still requires to be ledgered, the arrangement of the files is now complete and progress has been made in the filing of information. The photographic record is in full running order, and over 400 photographs have been card-indexed and mounted. Only a temporary office in the bazaar being available, little progress has been made with the research Library, and this must await more suitable arrangements being made for housing it. One residence for a Research Officer has been provided and a second is being built, so there are possibilities of the projected Research Institute being started before very long if funds and staff are available.

Mr. H. S. Single, Assistant Conservator of Forests, was attached from the commencement of the year until the end of February and did good work in arranging ledger files during the rains. Mr. F. W. Withers on appointment to the Department in December was attached to the Silviculturist for the rest of the year.

Maung Kaw Wun, Ranger, was attached throughout the year; and Maung Sein Gyi, Ranger, who had been attached to the Divisional Entomologist, was transferred to the Silviculturist when that officer went on leave, and has remained so owing to the temporary abolition of the post of Divisional Entomologist. Both these Rangers have proved themselves to be most efficient and are thoroughly competent to lay out sample plots and to work up preliminary figures for the plots. One sample plot party has now been fully trained and it is hoped to form a second party during the coming year. The position of the Burma Silviculturist, commented on in last Annual Report, has been made no easier by his having had to take

over charge of a Territorial Circle for 4 months of the year. The future of silvicultural research in this Province under these circumstances is not bright. No other senior officer can apparently be spared for the post without the same danger of his work being interrupted by his being called on to officiate as Conservator in a Territorial Circle. The obvious solution would be to allow the Silviculturist to remain in his post as officiating Conservator when his time came, just as Research Officers attached to the Forest Research Institute at Dehra Dun do. Unfortunately the Local Government do not seem to favour this solution. Another solution would be to transfer the Silviculturist Division to the Working Plans Circle—at present it is under the direct control of the Chief Conservator of Forests—and hand over the advisory work to the Working Plans Circle. If this were done the work of the Silviculturist, as far as experiments and statistical work go, could be done by a comparatively junior officer.

I.—*Experimental Silviculture.*

General.—A number of experimental plots have been laid out during the year mainly with a view to discovering the advantages or disadvantages of burning in young regenerated crops, the best times and intensity of weeding in such crops, and the effect of transplanting of seedlings and stumps of different sizes. Results have been most conflicting and show the impossibility of drawing any conclusions from isolated cases. So many different factors go to influence a forest crop that it is almost impossible to eliminate the effect of all other influences save the one the effect of which it is desired to prove. The true effect of a certain operation can only be definitely settled after continued experiments covering a number of years, but the conflicting results obtained in the present year can only go to show that some of the operations carried out, such for instance as stubble-burning in the hot weather following the year of formation of a teak plantation, do not in ordinary circumstances have any very material effect, either beneficial or the reverse, on the subsequent growth of the plantation.

Natural regeneration including coppice, root-suckers, etc.—The natural regeneration of *Dipterocarps* has received some attention. Plots were laid out to determine the best conditions for favouring the natural regeneration both of *in*, (*Dipterocarpus tuberculatus*) and *kanyin* (*Dipterocarpus turbinatus*) in Katha Division. Both these species seeded well in the hot weather of 1922. The natural regeneration of *kanyin* under suitable conditions and in the presence of good seed bearers can be very profuse indeed. Two adjacent plots totalling 1.04 acres selected under a fine group of seed-bearers with little under-growth but complete overhead cover were found to contain 30,851 seedlings. A recount at the beginning of the rains of 1923 has given 29,395 seedlings so the mortality during the hot weather has been under 5 per cent. The leaf cover had been burnt previous to the fall of the seed in 1922 and during 1923 the area has been carefully fire protected. Four other plots of 1 acre each were laid out to determine the best condition for regeneration of *kanyin* 5,000

seeds being sown in each. Unfortunately the experiment was tried of encouraging the seeds to germinate before being sown by keeping them moist in heaps and then sowing when the rains had fairly settled in. This was a mistake, as undoubtedly many of the seeds from which the radicle had emerged were sown so that the radicle could not get into the soil immediately, and consequently dried up.

The following table gives the results of these experiments to date.

Plot No.	Conditions of plot.	Percentage of seeds that germinated and survived up to November 1922.	Mortality percent during hot weather 1923.
Pinwo			
1	In the open after clear felling	9	23%
2	Under dense low cover not burnt before sowing.	26.0	6.5%
3	Under dense low cover, a leaf fire before sowing.	14.0	Nil
4	Under wood and low cover cut and burnt leaving a scanty overwood.	5.3	4%

The superiority of Plot 2 to Plot 3 is not altogether understood and is not believed to be a true result. The experiment was however rather spoilt by the seed being allowed to germinate before being sown. *Kanyin* seed can keep fairly well for about a month and it is by no means essential to allow it to germinate immediately as is the case with *sal* or *ingyin* (*Pentacme suavis*). The results show the necessity of shade for the successful germination of *kanyin*, and also for the survival of it through the hot weather. The comparatively low mortality per cent in plots 1 and 4 is due entirely to the protection given by a dense weed growth.

These results and the excellent natural regeneration of *kanyin* found in a *yemano* (*Gmelina arborea*) plantation in Mu Division from seed bearers on the edge of a plantation suggest that there should not be much difficulty in reproducing *kanyin* under a young plantation of a fast growing species by broadcast sowing provided the area is carefully fire protected. The excellent growth of natural *kanyin* in teak plantations of poor quality in the Magayi forests in Insein Division also goes to show the possibility of this. Here the *kanyin* (in this case *Dipterocarpus alatus*) has come in naturally and is now growing right through the teak canopy. In the presence of *kanyin* seed bearers the one essential to natural regeneration appears to be continued fire protection.

No very conclusive results were obtained with *in* (*Dipterocarpus tuberculatus*). Experiments are continuing.

Seeds.—Arrangements for the supply of seeds both for regeneration purposes within the Province and to outside indents has again been made where possible. The crop of seed of teak, *pyinkado*, (*Nydia dolabriformis*) and *taukkyun* (*Terminalia tomentosa*) in 1922 was very bad. For teak and *pyinkado* in many cases seed of previous year had to be relied on, with but poor results. The teak seed of 1921 had been very good and large stocks had been collected and stored. The failure to germinate in 1922 is possibly due to the hardening of the outer cover, which thus became imprevius to water and prevented the combined action of heat and moisture on the internal shell, which had also probably hardened by being stored. The plantations of 1922 have been very adversely affected by this scarcity of good seed.

Nursery work.—This has been extended in connection with the planting of *Eucalypts* in Maymyo and in the Bilumyo Reserve in connection with regeneration under the Mohuyin Working Plan. The nursery established in Zigon had been badly made and was abandoned. Regular nursery work is hardly necessary in connection with the ordinary *taungya* regeneration work in Lower Burma. On the whole nursery work in connection with the *Eucalypts* has been fairly successful; but it still remains to be proved that *Eucalypts* raised in the nursery can be transplanted economically and successfully in the forest.

In Bilumyo Reserve experiments with a number of species are continuing. The paramount importance of careful nursery work in connection with the raising of seedlings of *segawn* (*Michelia Champaca*) was very clearly shown by the success in carefully shaded and tended nursery beds as compared with complete failure in the open.

Artificial regeneration. Teak.—Owing to the poor results obtained from the teak seed of the previous year resort had to be made in many places to stumps. In Katha excellent results were obtained in Bilumyo Reserve in areas in which planting had failed in the previous year, the stumps attaining a height of 6' during the year. In Lower Burma however the success of teak stumps has never been so conspicuous; and although this is partly due to the slovenly way in which many of the teak stumps have been prepared for planting; it is also probably due to climatic conditions and the greater rapidity with which rot sets in. Possibly also the greater proportion of clay in the soil renders the conditions less favourable. Nevertheless with more careful planting methods, the use of stumps in filling blanks, especially early in the second rains, is of great benefit.

Eucalypts.—The spot sowing of *Eucalypts* in the regeneration area in Maymyo Reserve was a complete failure. Seed germinated in many cases fairly satisfactorily but practically all of it died off soon after. There can be little doubt that so delicate species as *Eucalypts* can only be reared under careful nursery treatment. Experiments in transplanting from nurseries by different methods are now being carried out.

Mr. Barrington has shown that *padauk*, both Burmese, (*Pterocarpus macrocarpus*), and Andaman (*Pterocarpus dalbergioides*), can be successfully reproduced from cuttings. He has also been successful in transplanting *ingyin* (*Pentacme suavis*) and *thiyya* (*Shorea obtusa*) from nurseries. Whether these seedlings will thrive after transplanting or remain stationary, as is believed to have been found in the case of *sal*, has yet to be seen.

Reclamation and Afforestation.—In the reafforestation work in the Bhamo Kachin Hills the success of broadcast sowing of *Maibau* (*Alnus nepulensis*) on bracken-infested slopes seems to be fairly proved. The essential condition for successful afforestation seems to be successful fire protection.

Thinnings and Cleanings.—Considerable attention has been paid during the year to the question of early thinnings in teak plantations. First thinnings were carried out in young plantations of ages varying from 6 to 10 years old. It was found that in an ordinarily vigorous and well-stocked plantation suppression of individual stems had already commenced in the 7th year and a thinning on purely mechanical lines, i.e., the removal of every alternate tree, was no longer possible. Moreover the effect on the crowns by competition had by the 7th year already become serious. The underlying idea of early thinning is to avoid the restriction of the crowns, as it has been found that not only does the increment fall off appreciably, but that once restricted the crowns do not respond rapidly to thinnings. It is believed that the close of the 6th year is as long as thinnings should be put off in an ordinarily vigorous plantation planted originally 6' x 6'. In vigorous plantations a thinning at 5 years or even earlier is undoubtedly essential; and it may be noted that a small group of trees thinned early in their 4th rains showed within a year an increased girth increment of over 2" as compared with trees unthinned in close proximity. Such early thinning however sacrifices shape and quality of timber to increment and it is thought best in any case to leave the thinning until the end of the 5th rains in order to allow the lower branches to be killed off. In a good *yemane* (*Gmelina arborea*) plantation the age for thinning is about one year earlier. With regard to mechanical thinnings these were in no case found to be practicable. Burma teak plantations are naturally made on rougher lines than in Nilambur, and absolutely complete stocking is rarely attained. Under the circumstances an occasional blank in the spacing throws out the regularity of the thinning. However, what may be known as a modified mechanical thinning can usually be carried out; the object being to space the remaining trees out so as to avoid any wide gaps, and at the same time to avoid leaving any two trees standing at the original spacing. Two blanks together are usually preferable to two trees being left only 6' apart. The results of these early thinnings have yet to be seen but there can be little doubt that the increment will be very greatly accelerated. A point worthy of mention is that it has been found that thinnings especially in young plantations should as far as possible be carried out only after the rains. During the rains the stems are sappy and

not elastic, and do not recover after being bent over, an unavoidable injury when thinning in densely stocked plantations.

Miscellaneous. Burning and Fire protection.—In last year's Annual Report considerable importance was given to this subject owing to the extensive experiments undertaken in teak plantations by Mr. Dawkins in Zigon Division. These experiments and their results may be summarised as follows.

Burning of the straw in taungya plantations in the early part of the hot weather following formation :—Further experiments in this operation have given most conflicting results and tend to prove that the operation is only of value in the case of a plantation that has not been kept well weeded by the cultivator. Further research is however necessary.

Cutting back and burning.—Only a very light weeding was done in the second rains, sufficient to keep back the worst of the weeds. The whole growth was then cut back in the cold weather of the second year and burnt as soon as dry. It was hoped by this operation to establish the plantation with little further expense and avoid the use of labour in the rains when it was thought to be hard to obtain. The result is a very complete failure. In the first place early weeding is essential to ensure the vigorous growth of the teak, much of which is otherwise suppressed in a dense mass of weeds. In the second place the cutting back in the cold weather was found to be more expensive than weeding during the rains while, instead of a well-established plantation such as would have been the result of thorough weeding in the second rains, the result of burning was a dense thicket of teak stool shoots with a strong growth of grass and weeds which still required attention at considerable cost.

Aids to regeneration such as the formation of a dense stock of accessory species may be devised to reduce the cost but no method can succeed which ignores the importance of ensuring an early vigorous growth of the teak.

Early burning of all plantations.—It was hoped by this to reduce the cost of fire protection and avoid the very serious danger of an accidental fire late in the season. Unfortunately early burning does not avoid damage entirely, and in the case of young plantations this danger is often serious. In most teak plantations over a year old, at any rate in Zigon Division, there is always a certain amount of tall grass. This grass in the course of three or four years fire protection becomes suppressed under the canopy of the teak and dies out. Early burning has to be repeated in order to reduce as far as possible the inflammable material that might give rise to a late fire, the idea being to put a number of successive light fires through the plantation. Once a clump of grass ignites however the fire cannot be termed light, and all teak saplings in the vicinity are burnt back or badly damaged. This causes a gap in which the grass has every opportunity of spreading. In the following year it burns again repeating the damage and expanding the gap.

Another probable consequence of this so-called early burning is the scorching of the leading shoot this causing the sapling to fork. Fire protection must be considered essential and most careful measures must be taken to see that it is successful. Only after successful fire protection can the canopy close up and kill out the grass, when fire protection can be given up for early burning. This will ordinarily not be possible for at least 5 years after formation of the plantation.

II.—Working Plans and Statistics.

(Sample plots.)

(i) *Yield tables*.—Considerable progress was made during the year in laying out sample plots. The following gives the results of the season's work.

<i>Teak</i> .				
Volume increment per acre	..	..	..	47 plots.
<i>Yemane (Gmelina arborea)</i> .				
Volume increment per acre	..	..	..	2 plots.
<i>In. (Dipterocarpus tuberculatus)</i> .				
Volume increment per acre of young and middle aged pole forests	..	..	..	9 plots;
Girth and diameter increment of single trees (old plots re-organised)	..	..	..	8 plots, 80½ trees.
<i>Ingyin (Pentacme suavis)</i> .				
Diameter increment of single trees	..	..	..	1 plot 80 trees.
<i>Kanyin (Dipterocarpus turbinatus)</i> .				
Diameter increment of single trees	..	..	..	1 plot 59 trees.
				68 plots.

The majority of the teak sample plots were taken in the younger age classes, but some good sample plots were obtained in the Pyonchaung plantations in North Toungoo Division at an age of over 50 years. Plots in plantations up to the age of 35 are now sufficient to draw up a rough yield table; but it is extremely difficult to obtain plots in plantations formed between the years 1870 and 1887. A few good sample plots in plantations of these dates are very urgently required. So far all plantations of these dates inspected are so uneven that it is impossible to obtain plots of half an acre of well stocked forest. Failing actual plots experiments will be made of building up a composite plot from typical groups which may give sufficient data to give a rough yield table.

The nucleus for two sample plot parties is now available but funds are likely to prevent the entertainment of the full necessary staff.

(ii) *Volume tables*.—A rough volume table for teak for Tharrawaddy Division was issued as Burma Forest Bulletin No. 6. Volume tables for other important species are being compiled and it is hoped to publish them shortly.

A number of silvicultural photos have been taken during the year. The whole collection has now been properly indexed and mounted and already contains over 400 photographs, for many of which negatives are also available.

ANDAMANS.

No information forthcoming.

CENTRAL PROVINCES.

I.—*Experimental Silviculture.*

General.—Silvicultural research in the Central Provinces previously confined to sporadic and individual efforts in an infinity of directions, was at last guaranteed continuity by the creation of the post of Silviculturist. The Hon'ble J. W. Best, I.F.S., was appointed, with Mr. V. K. Maitland, I.F.S., as assistant, in October.

The season's work comprised the survey of information ready for disposal (statistics collected in the past being called for and worked up); the measurement of coppice shoots of known age in widely different localities in the Southern Circle to determine the existing rates of growth of the more important species; the measurement of as many old teak plantations as possible to fix the existing average girth, height, and volume per acre of our teak grown in pure woods; the inspection and where necessary the thinning of established sample plots to determine the volume increment per acre of pure woods of other species; and the laying out of experimental plots to ascertain the best method of establishing the more valuable species by regeneration fellings.

Information collected in the past.—The records of old and existing sample plots reveal the fact that most of our species at present have appallingly low growth increments. This is largely due to the neglect of cultural operations, and our past figures can only be used for comparison with those to be derived from the thinned crops of the future. The sal (*Shorea robusta*) of 6 feet girth takes on an average 175 years to grow, according to our old records, a period which it is now believed can be reduced to at most 100 years under more enlightened treatment. All sample plots now laid out are thinned and measured on the Dehra Dun lines so that the increment of thinned crops will before long be available. Probably the most important result of the examination of old and existing plots, etc., was the abandoning of experiments which had outlived their usefulness; or which as silvicultural blind alleys were involving much waste of time and labour.

Coppice Measurements.—In varying localities coppice shoots of different qualities capable of forming part of the final crop under the present rotation of 30 years were measured for girth and height. An arithmetical average was taken for each locality for each age gradation, and used as a point in the drawing of a curve for each species. From the curves the final results of, for the example given—

below were read off, and are intended as a general provincial average only. It was found that the average rate of growth of our coppice shoots is practically constant for a given species throughout the province. Figures were obtained as in the following example :—

Species.	Age.	MEAN GIRTH IN INCHES.		MEAN HEIGHT IN FEET.		Average number of shoots per stool.	Total number of shoots measured.
		Class IV-a.	Class IV-b.	Class IV-a.	Class IV-b.		
Teak ..	5	5.0	3.6	11.2	10.0	1.7	722
	10	8.0	6.5	18.5	14.8		
	15	10.8	9.0	21.0	18.1		
	20	13.2	11.0	28.5	21.4		
	25	15.3	13.1	32.1	21.4	1.5	
	30	17.2	15.0	35.8	27.0		

The above refer to shoots with a possible future under the present system, which does not cater for a thinning of any sort ; and show the falling off in increment in the 20th or 25th year when the cramping effect is felt.

Measurement in pure woods.—At present the only pure, full stocked woods at our disposal are old teak plantations and patches of sal or girgari (*Gleistanthus collinus*). A beginning was made by the laying out of 18 sample plots in the teak and 9 in sal and girgari areas, all on Dehra Dun lines. The Imperial Silviculturist undertook the laborious task of working up the results and the delicate one of suggesting necessary improvements in method.

Thinnings.—Thinnings were begun in the Melghat Division in the Pili teak plantation and in South Chanda and other divisions in congested crops. It has been shown by experiment in several localities that thinnings are by no means impracticable in the province, and that they may be a source of considerable revenue if carried out in well chosen areas.

In all coupes one of the stems of forked teak was cut, and it is expected that this will stimulate increment in the remaining stem without producing decay.

Experimental patches to ascertain the extent to which teak will stand opening up of the overhead cover were also begun in the Melghat.

The importance of thinnings in crops already suffering from congestion and from the shade of the large spreading *mohwa* (*Bassia latifolia*), etc., and the decrepit standards which are the legacy of

former working under so called "Improvement Fellings", is now beginning to be realised generally; and the planting operations of former years must be abandoned in their favour.

Reproduction.—(a) *Natural.*—Sal regeneration experimental areas were laid out in the frost-labile areas of South and North Mandra.

(b) *Artificial.*—Experiments in Berar with teak seedlings, *babul* (*Acacia arabica*) and *anjan* (*Hardwickia binata*) were continued.

II.—Working Plans and Statistics.

The system at present being used in the Central Provinces are coppice, coppice with standards (either simple or "combined with improvement fellings"), improvement fellings, and high forest. The general rotation adopted for all but high forest is 30 years, a period originally chosen purely as a convenient cycle when the need all over the province was the replacement of unsightly pollards, etc., by straight regrowth from stools. The majority of our working plans, some of which are now being used for the second rotation, are in urgent need of revision or rewriting. Stock maps are even more necessary, as large areas containing pole crops which have sprung up since the forests were reserved and protected, are now ready to be excised from the area under our jardinage and coppice treatment and put under high forest systems, with provision for thinnings which will increase the amount of species of quality in and consequently the future value of the forests of the Central Provinces to a degree hitherto not contemplated.

A welcome departure has been made in the South Raipur Division, where a preliminary working plan report has been drawn up and the division stock mapped with a view to working the sal forest under a uniform system.

Coorg.

Work was confined during the year to the preparation of *interim* statistics of the rate of growth of the principal evergreen and deciduous species by the measurement of selected trees. No results are yet ready for publication.

No further observations have been recorded on the experiments described on pages 26—28 of last year's report.

MADRAS.

General.—The programme was much the same as that of the previous year, and dealt chiefly with investigation into different methods of regeneration. Experiments were carried out in the Cheral Nair and Sappal valley forests, near Palghat, and at the foot of the Coorg ghats near Malat. Sample-plots and trees maintained for the collection of statistical data were identified and measured.

in Coorg, Nilambur, Tinnevelly and South Cuddapah Districts. Of these, sample plots of teak at Mundanthorai (Tinnevelly District) and of red sanders (*Pterocarpus santalinus*) at Kodur (South Cuddapah Division) were abandoned as being unrepresentative. Arrangements have since been made that all plots—sample and experimental—dealing with sandal and deciduous species in Coorg shall be maintained by the officers of that Province: the Madras Silviculturist to be immediately interested so far as Coorg is concerned only in the evergreen forests on the Ghat slopes.

I.—*Experimental Silviculture.*

General.—Sixty-two plots (experimental) were under the control of the Silviculturist at the beginning of the year: eight plots were added to the list and twenty-five removed during the year.

Natural Regeneration.—Five one-acre plots have been laid out in the Chenai Nair Reserved Forest to ascertain the best method of encouraging the existing natural regeneration and of inducing fresh regeneration of the more valuable species in an evergreen type of forest, as a preliminary to the final felling of the overwood when the crop will be fully exposed to the sun.

Five half-acre plots have been laid out in the Nalkore Reserved Forest to compare different methods of uncovering young *Hopcia* seedlings in an evergreen type of forest. At present the best results obtain in the plot from which all shade was removed. In support of this it is noticeable that all the plots are bounded on one side by a fire-line, and all along this fire line the seedlings have attained a height considerably greater than the average height of their plot.

Two two-acre plots were laid out in 1922 in the Anaigundy Reserved Forest in mixed evergreen forest when the ground was well covered with young seedlings of *Hopcia parviflora*.

The object is to note the difference in effect on the young seedlings—

(a) when they are suddenly exposed to direct sunlight in February, *i.e.*, at the most unfavourable time of year,

(b) when they are partially exposed in June, *i.e.*, at the most favourable time of year.

After one year the aspect of plot (a) is not encouraging. The number of seedlings has very considerably diminished and the height, growth of the survivors is poor. The Forest Research Officer examined a few seedlings on the area, and found them lacking in depth of root which would account for their failure to survive exposure to a hot sun. From this and from results obtained by sowing and planting in the shade it would appear that seedlings under shade

do not strike deep, as they can find the requisite moisture near the surface ; and that seedlings which have never been under shade will have formed roots in their first growing season long enough to supply them with moisture during the hot weather.

To note the progress of regeneration after exploitation in Chenat Nair Reserved Forest a clear-felled area of about 8 acres has been selected for observation. All seedlings have been enumerated, and 25 seedlings each of *Mesua ferrea*, *Calophyllum tomentosum*, *Dichopsis elliptica* and *Cullenia excelsa* have been staked for annual measurement. The area is to be weeded (August) and enumerated (May) annually.

Five one-acre plots were laid out in 1920 in Parappa Reserve Forest to compare the result of uncovering by different degrees young seedlings of *Hopea parviflora* which are the result of broadcast sowings under natural shade in 1910-11. Progress is being noted.

Six two-acre plots were laid out in June 1922 in Parappa Reserved Forest to discover how soon *Hopea* seedlings can be uncovered. The seedlings are the result of dibbling in 1920, and shade is being removed by varying degrees.

Seeds.—Results of germination tests.—The following species have given 50 per cent. success or more when kept for 15 days or longer under ordinary conditions.

Vateria indica kept for 34 days gave 97 per cent.

Hardwickia pinnata kept for 26 days gave 73 per cent.

Xylia xylocarpa kept for 15 days gave 63 per cent.

Balanocarpus utilis kept for 33 days gave 52 per cent.

Bombax malabaricum kept for 86 days gave 50 per cent.

Other results :—

Gmelina arborea kept for 1 day gave 94 per cent.

Gmelina arborea kept for 15 days gave 46 per cent.

Gmelina arborea kept for 30 days gave 40 per cent.

Mangifera indica kept for 3 days gave 43 per cent.

Mangifera indica kept for 17 days gave 21 per cent.

Good germination has not been obtained from untreated seeds of *Hopea parviflora* more than 8 days old.

The best results are—

7 days old under shade and watered daily 75 per cent.

7 days old in the open 74 per cent.

7 days old covered with brushwood and watered daily 82 per cent.

Artocarpus brought to Chenat Nair Reserved Forest from North Mangalore has given 35 per cent. success from 17 days old seeds.

Seeds 3 days old have given $\left\{ \begin{array}{l} 100 \text{ per cent.} \\ 88 \text{ per cent.} \end{array} \right.$

Seeds 7 days old have given 65 per cent.

Bischofia javanica seeds 7 days old have given 24 per cent.

Bischofia javanica seeds 14 days old have given 16 per cent.

Bischofia javanica seeds 28 days old have given 21 per cent.

Gluta travancorica seeds brought to Chenat Nair from Tinnevelly District have given 30 per cent. success when 10 days old.

Terminalia tomentosa—

Seeds 90 days old untreated gave $\left\{ \begin{array}{l} 10 \text{ per cent.} \\ 16 \text{ per cent.} \\ 26 \text{ per cent.} \end{array} \right.$

Seeds 90 days old boiled gave 29 per cent.

Seeds 91 days old soaked for one day 32 per cent.

Soaking appears to assist germination.

Artificial Regeneration.—Five plots in Chenat Nair Reserved Forest in an evergreen locality deficient in natural regeneration were artificially stocked in 1921 by dibbling *Hopsea parviflora*, *Artocarpus hirsuta*, *Mangifera indica* and *Dichopsis elliptica*. In 1922 a different degree of shade was removed from each plot. In the plot from which all shade was removed the regeneration entirely died out during the hot weather of 1922. In the other plots natural regeneration is now much in evidence and its progress will also be noted.

To discover whether some of the more valuable evergreen species can be established by sowing or planting on prepared soil in the open, one half-acre plot was clear-felled in February, 1922 in the Sappal valley, Chenat Nair Reserved Forest on first class soil. The debris was burnt and pits were dug and the soil weathered. In June 1922 the following species were sown and planted :—

- (a) *Hardwickia pinnata*.
- (b) *Calophyllum tomentosum*.
- (c) *Valeria indica*.
- (d) *Bischofia javanica*.

(e) *Hopea parviflora*.(f) *Artocarpus hirsuta*.

Species.	No. of pits sown.	PERCENTAGE OF SUCCESS ON		Average height.	Number transplanted.	PERCENTAGE OF SUCCESS ON		Average height.	REMARKS.
		25th Sept. 1922.	23rd April 1923.			25th Sept. 1922.	23rd April 1923.		
<i>Hardwickia pinnata</i> .	40	87.50	5.00	7"	40	70.00	42.50	9"	Many of the seeds did not germinate till the end of September.
<i>Calophyllum tomentosum</i> .	50	Nil.	Nil.	..	38	89.5	Nil.	..	
<i>Vateria indica</i> .	40	100.0	100	1' 3"	40	100.0	47.50	1'	Transplants damaged by sambur.
<i>Bischofia javanica</i> .	40	Nil.	Nil.	..	40	100.0	95.00	3' 2"	
<i>Hopea parviflora</i> .	50	90.0	8.00	1' 3"	50	98.0	62.00	1'	
<i>Artocarpus hirsuta</i> .	50	100.0	92.0	1' 9"	50	76.0	28.0	1' 2"	

If any conclusion can be drawn after one year the following results may be noted :—

- Hardwickia pinnata* seeds took a very long time to germinate, and this accounted probably for their failure in the hot weather.
- Calophyllum tomentosum* failed entirely. The Research Officer has noted that seedlings of this species thrive better under heavy shade than many other evergreens.
- Vateria indica* sowings are giving a better result than transplants.
- Bischofia javanica* transplants are most successful.
- Hopea parviflora* transplants have done much better than sowings.
- Sowings are much more successful than transplants and seedlings are so numerous that 6" x 12" pots should be ample.

To compare the results of sowing and planting evergreen species on prepared and unprepared soil six small plots were laid out in the Sappal valley, Chenat Nair R. F. and the following species experimented with :—

- (a) *Artocarpus hirsuta*.
- (b) *Bischofia javanica*.
- (c) *Vateria indica*.
- (d) *Mangifera indica*.
- (e) *Hardwickia pinnata*.
- (f) *Calophyllum tomentosum*.

The smaller trees of useless species were removed to admit more light to the area.

The results to date are as follows :—

Species.	Date of sowing or planting.	NUMBER OF PATCHES.		NUMBER OF PITS IN WHICH SURVIVALS WERE FOUND ON 23RD APRIL 1923.			
		Prepared soil.	Unprepared soil.	Prepared soil.	Average height.	Unprepared soil.	Average height.
<i>Artocarpus hirsuta</i> seeds	16th May 1922.	100	100	69	8"	78	8"
<i>Artocarpus hirsuta</i> transplants.	28th May 1922.	100	100	30	9"	15	9"
<i>Bischofia javanica</i> ..	seeds were not available at that time.						
<i>Bischofia javanica</i> transplants.	28th May 1922.	100	100	74	2' 9"	16	2' 4"
<i>Mangifera indica</i> seeds	12th June 1922.	100	100	74	1' 11"	57	1' 11"
<i>Mangifera indica</i> transplants.	12th June 1922.	100	..	..	..	..	..
	21st June 1922.	..	100	74	1' 11"	65	1' 11"
<i>Calophyllum tomentosum</i>	seeds were not available at that time.						
<i>Calophyllum tomentosum</i> transplants.	20th July 1922.	100	100	77	10"	67	10"
<i>Hardwickia pinnata</i> seeds	21st June 1922.	100	100	58	10½"	30	10½"
<i>Hardwickia pinnata</i> transplants.	8th July 1922.	65	..	18	10½"	..	..
<i>Vateria indica</i> seeds ..	14th June 1922.	100	100	75	13"	98	13"
<i>Vateria indica</i> transplants.	14th July 1922.	100	100	55	12"	57	12"

The percentage of greater success on the prepared soil is probably not sufficient to warrant the extra expense, with the possible exception of *Bischofia javanica*.

It is interesting to compare this experiment with the previous one, and to note that in each case sowing of *Artocarpus hirsuta* has proved more successful than transplanting. *Artocarpus hirsuta* sowings and transplants and *Bischofia* transplants show better growth in the open : but the difference is likely to be more noticeable after the second growing season. In estimating the success of the experiment with evergreen species in the open unexpected rain in March must be taken into account.

Another experiment was initiated on the Sappal ridge of Chenat Nair Reserved Forest in a clear-felled area, where efforts to re-establish evergreens have met with small success, to compare the results of sowing and planting deciduous species.

The results to date are appended.

Species.	Date of sowing or transplanting.	Number of patches.	Number of survivals in April 1923.	Average height.
<i>Xylia dolabriformis</i> seeds ..	26th May 1922	200	184	7½"
<i>Xylia dolabriformis</i> transplants	26th May 1922	200	21	9"
<i>Gmelina arborea</i> seeds ..		No seeds	unavailable.	
<i>Gmelina arborea</i> transplants eight months old.	27th May 1922	200	46	3' 3"
<i>Terminalia tomentosa</i> seeds ..	27th May 1922	200	172	2' 11½"
<i>Terminalia tomentosa</i> transplants	23rd June 1922	200	149	3' 1"
<i>Lagerstroemia</i> seeds	30th May 1922	200	110	8½"
<i>Bombax malabaricum</i> seeds ..	Nil. (No seeds	were available).		
<i>Bombax malabaricum</i> transplants two months old.	4th July 1922	100	60	5"

N.B.—The figures in column 4 refer to the number of pits or patches containing survivals.

The plot will be retained till the effects of a second growing season and a second hot weather have been noted.

Transplanting.—To discover the effect of stumping evergreen seedlings of different ages, the following four species were experimented with in June 1922 :—

(a) *Mangifera indica*.

(b) *Hardwickia pinnata*.

(c) *Mesua ferrea*.

(d) *Calophyllum tomentosum*.

Seedlings of known age being unprocureable, 20 each of 2½', 3½' and 5', were collected, making 60 seedlings of each species, which were put out in the Sappal valley under the shade of natural ever-green forest with 4" root and 2" stem.

Survivals on 23rd April 1923.

Species.	2½'	3½'	5'	Average height of shoot.
<i>Mangifera indica</i>	2	Nil.	2	4½'
<i>Hardwickia pinnata</i>	11	14	10	1' 1"
<i>Mesua ferrea</i>	10	8	8	7½"
<i>Calophyllum tomentosum</i>	Nil.	Nil.	Nil.	..

It appears that only *Hardwickia pinnata* and *Mesua ferrea* are likely to be successfully regenerated in this manner.

Bombax malabaricum and *Gmelina arborea* were similarly dealt with in an open area near the Dhoni nursery. The survivals are given below :—

Date of transplanting.	Species.	Number of seedlings.			Results on 25th April 1923.		
		5'	3½'	2½'	5'	3½'	2½'
29th June 1922	<i>Bombax malabaricum</i> ..	20	20	20	5	5	8
30th June 1922	<i>Gmelina arborea</i> ..	20	20	20	15	15	14

Three plots in Parappa Reserved Forest were laid out to discover in what months and at what age *Hopea* seedlings may most successfully be transplanted, and also what the effect would be of such injury to the roots as might frequently result when pulling up seedlings to be transplanted. In one plot natural seedlings one year old were planted out on 5th July 1920, 2 and 3-year-old on 5th July and 4-year-old on 19th July; 25 seedlings with roots intact and another 25 with roots somewhat injured were planted in each case. The second was similarly treated with 100 seedlings in each case, age varying from one to five years. The conditions of locality were the same as in the previous plot, with this difference that the canopy was generally more open here than in the previous plot owing to the opening caused by the felling of a bamboo clump on the area in 1920.

The third also was similarly treated with 100 seedlings in each case. The soil is laterite of 2nd class quality and fairly deep. Undergrowth consisted chiefly of *Aporosa*. Overwood consisted of deciduous trees such as *Terminalia*, *Xylia* and *Lagerstroemia*. The percentage of survivals as observed in October 1922 is appended below :—

No.	Date of planting.	Number and age of seedlings.	PERCENTAGE OF SURVIVALS IN OCTOBER 1922 OF	
			Those plant- ed with roots intact.	Those plant- ed with roots injured.
I	4th July 1920	25, one year	64	48
		25, two years	68	76
	5th July 1920	25, three years	68	76
	10th July 1920	25, four years	56	56
II	7th August 1920	100, one year	51	10
		100, two years	10	11
	8th August 1920	100, three years	45	33
		100, four years	44	61
		100, five years	51	62
III	9th November 1920	100, one year	16	27
		100, two years	13	3
		100, three years	17	9
		100, four years	22	16

Seedlings of known ages not being available, ages were estimated as follows :—

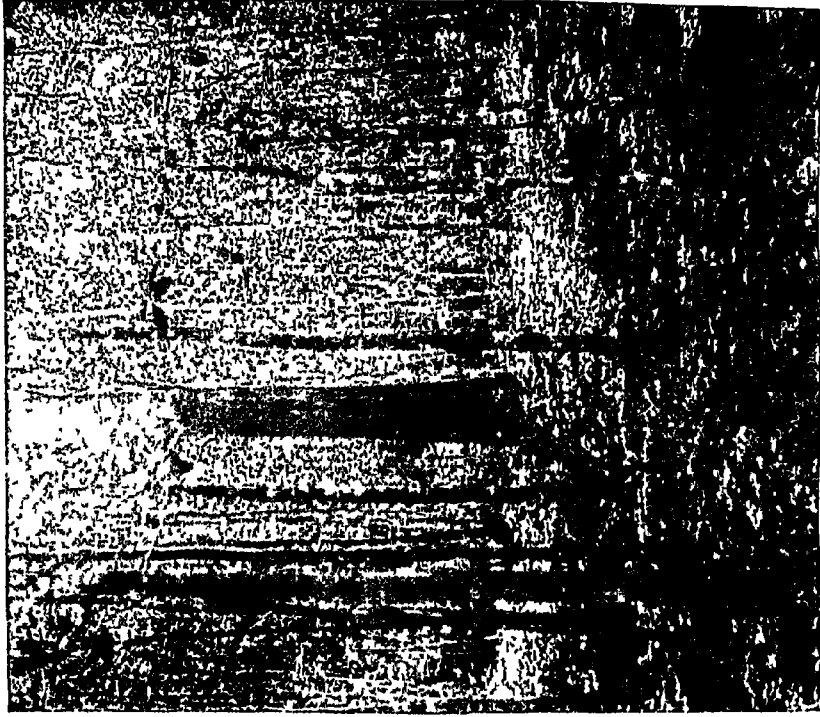
0" — 4" to be 1 year old,
4" — 6" to be 2 year old,
6" — 9" to be 3 year old,
9" — 12" to be 4 year old,
12" — 15" to be 5 year old.

The experiment shows that injury to roots has little or no effect, especially in the case of larger seedlings; and that the age of the seedlings put out is immaterial, and also that seedlings should not be transplanted later than the beginning of August.

To discover whether the stumping of young sandal seedlings will promote a quicker growth in the early stage, 40 young sandal seedlings of approximately one year growth were selected from the Burliar reserve and stumped, 4" root and 2" being left. An area under light shade was selected near 5th milestone from



18 years old *Artocarpus hirsuta* sown broadcast
under tank 30 years old. Travancore.



Artocarpus hirsuta 18 years old under tank
57 years old. Travancore.

Ootacamund just off the road. 20 stems were put out in bamboo tubes and 20 directly into prepared pits. The plants were watered until showers became regular. On the 30th September 1922, 36 stems were found to possess shoots; of the remaining four, one was probably dead. On 23rd April 1923, 12 were found to survive of those in pits and 10 of those in bamboo tubes. The average height of the coppice shoots was 4.2" in respect of those in pits and 3.3" of those in bamboo tubes. Unless these seedlings grow very vigorously during the coming growing season this method will show no improvement over direct sowings.

Underplanting.—Reference is invited to an article in the "Indian Forester" for May 1923 on a successful introduction of *Artocarpus hirsuta* under teak in Travancore. The accompanying photograph illustrates this experiment.

II.—Statistics.

Four plots in the teak plantation of Nedungayam, South Malabar Division, were remeasured during the year. Two plots, one very heavily thinned and one moderately heavily thinned in 1916-17 are in the 1909 plantation, and two similarly treated are in the 1907 plantation. The heavily thinned plots show a greater average increase in diameter per stem than the moderately thinned plots, but the latter contain more stems per acre and as yet have a greater volume of wood as the following figures show :—

Plot No.	How treated.	Average increase in diameter since 1916-17.	Average diameter per stem in 1923.	Number of stem per acre.
1	Moderately heavily thinned ..	1.79"	6.85"	308
2	Very heavily thinned ..	2.25"	7.87"	194
3	Moderately heavily thinned ..	1.88"	6.32"	316
4	Very heavily thinned ..	2.80"	6.06"	200

PUNJAB.

I.—Experimental Silviculture.

Complete reports on experiments with a view to determining the best method of regenerating spruce and fir forests are not available. In one instance in Kulu a abundance of seedlings on ground where felling refuse has been raked only, and the smaller number on ground well raked only, and the absence of seedlings on untouched ground is recorded. Data on 10' wide had been felled in the mixed spruce and fir forest, and the refuse had to be burnt in June as it would not burn in autumn. Fir seedlings are more

abundant than spruce, and both are observed to be confined to the lower side of the strip, which lies on a northerly aspect ; both observations suggest insufficient light in the strip as a whole. Precise information is not available with regard to the raising of food or fodder catch crops as a prompt and economical means of establishing deodar. In some instances there has been some confusion of means and end ; and on the whole it seems that the indolence of the people precludes success on any considerable scale.

Records of past observations in the Hoshiarpur Division in the course of experiments to determine the best rotation for cutting bamboo; are open to doubt and no conclusions can be drawn. As regards the Pabbi afforestation, it is now clear that success is attainable by works of considerable complexity as regards earth ' bands ' and trenches. Some four hundred acres have been successfully treated and are already producing crops of *Acacia arabica* and good fodder grass.

No fresh research was undertaken during the year ; but the Punjab Government sanctioned the creation of a Working Plans and Research Branch after the close of the year ; and it is hoped that research work will now be undertaken on regular lines as soon as an adequate staff becomes available.

The Khairimurat Olive Plantation had to be abandoned during the year, as it has been proved that the success of an olive plantation depends greatly on water and that the shortage of rain affects the fruit yield very badly. Consequently the small rainfall near Rawalpindi was an insuperable obstacle to the success of the experiment.

The propagation of lac in the Hoshiarpur Division was continued satisfactorily, but at the end of the year the swarming insects were destroyed by heavy hail storms, and in consequence no sales of lac were made during the year. At the end of the year only one hundred and sixty trees remained which had been definitely infected ; but it is hoped that next year progress will be more satisfactory, provided no disasters such as heavy hail storms at the time of swarming occur again.

The experiments in regard to the rotation for cutting bamboos were continued in the Kangra and Hoshiarpur Divisions, and it has been ascertained that biennial cutting gives the best results and can safely be introduced. The following account shows the procedure followed in the Kangra experiment.

A sample plot for ascertaining the best bamboo cutting rotation was laid out in Dhamtal Reserve, Nurpur Range, in 1916-17. It contains thirty clumps which had been thoroughly cleaned before the plot was laid out, and their measurements recorded. These clumps were serially numbered, and the number of shoots produced during the two previous monsoons ascertained. One-third of these clumps was to be felled every first year, one-third every second year, and one-third every third year.

Mr. Walters, Deputy Conservator of Forests, laid out the following rules when the plot was started :—

General—

1. All shoots to be cut within one foot of the ground.
2. No portion of the cut shoots to be left in the clumps.
3. No shoots of this year and of the previous year to be cut.
4. Shoots left uncut to be evenly distributed over the clump.
5. Outside shoots, unless dead, not to be cut.

Special—

1. From one year rotational clumps not more than half the living old shoots to be cut.
2. From two years' rotational clumps not more than two-thirds of the living old shoots to be cut.
3. From three years' rotational clumps not more than three-fourths of the living old shoots to be cut.

Revised Rules 1918-19.—In 1918-19 the special rules were discontinued because it was realised that the number of old shoots to be cut might depend entirely on the condition of the clump, leaving sufficient stems to support the *manus*. General Rule No. 3 was also modified to the extent that useless, crooked and top broken shoots less than two years old might also be removed at the time of cutting.

Method of recording data, 1916-17.—The data were recorded separately for each year. A definite procedure was laid down in 1918-19 and the following rules were framed :—

1. Felling to be done not later than the end of December each year before the *manus* become indistinguishable.
2. Before felling all the stems in each clump to be counted and checked with previous years' figures.
3. The *manus* of the year to be counted and recorded according to their classes.
4. When felling clumps, the cut shoots to be classified and recorded.
5. Current year's *manus* to be marked with one coal tar ring and one ring to be added to all other previously marked shoots. Previous year's marking to be refreshed if necessary.
6. The shoots remaining in the clumps should then be counted and recorded.

On inspection in 1918-19 it was found that three years' rotational clumps were beginning to become congested. It was too difficult for a foot to fall them thoroughly. He could only skim round the outside. On the other hand the one year rotational clumps were too open. As was expected, the one year and two years' rotational clumps produced more shoots than the congested three years' clumps. It was realised that the best and the most accurate results would have been obtained if all the clumps in the plot were more evenly developed. At the time the plot was laid out the

In 1921-22 the rotational period of all the clumps expired, and consequently all were felled according to the rules mentioned above. The data for the six years period ending in 1921-22 were collected and the following results obtained :—

1. The total number of shoots in clumps prescribed for yearly cutting was 206 in the beginning of the experiment. 435 new shoots were obtained during the six years period. Thus the increase of shoots over the number at the beginning of the experiment comes to 211.2 per cent. or 35.2 per cent. per annum, and marketable 142 per cent. for six years and 23.6 per cent. per annum.
2. The total number of shoots in clumps prescribed for biennial cutting was 208 at the commencement of the experiment. 519 new shoots were produced during the six years period. Thus the increase of new shoots over 208 in hand at the commencement of the experiment amounts to 249.5 per cent. or 41.6 per cent. per annum, and marketable 142 per cent. for six years and 23.6 per cent. per annum.
3. The total number of shoots prescribed for triennial cutting was 232 when the experiment was taken up. 430 new shoots were obtained during the six years period. The increase of new shoots over 232 of the old ones comes to 185.35 per cent. or 30.89 per cent. per annum, and marketable 113 per cent. for six years and 18.83 per cent. per annum.

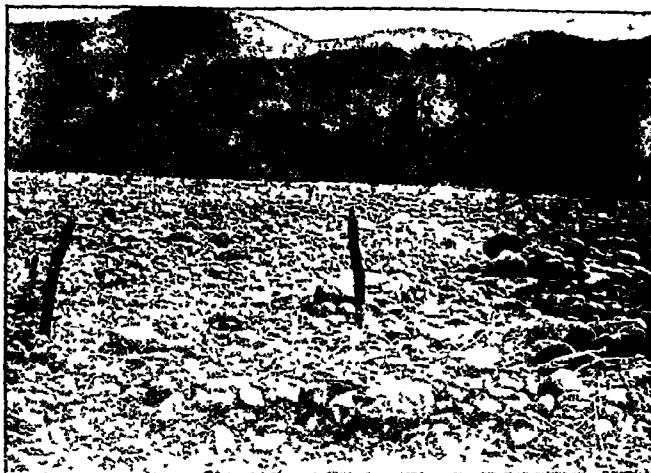
From the results noted above it is evident that the clumps under biennial cutting rotation have given the highest percentage of new shoots, i.e., 41.6 per cent. per annum against 35.2 and 30.89 per cent. per annum for annual and triennial cutting rotations respectively ; and of marketable shoots cut, i.e., 23.6 per cent. per annum against 23.6 and 18.83 per cent. per annum for annual and triennial cutting rotations respectively.*

The experimental rearing of belladonna in the Simla Division mentioned in the last year's report has proved a failure and has been abandoned.

The experimental sowings of *Eucalyptus* species in the Kot Lakhpat plantation have been stopped on account of the sale of the plantation to the Model Town Society, Limited, Lahore. The work will be continued in other irrigated plantations. Experiments are now being made with sowings of maritime pine in irrigated plantations.

In the Rawalpindi East Division sample plots have been started to determine the effect of resin tapping on the girth increment of *chir* trees.

*The application of the results of this experiment to bamboo felling on a large scale must depend on adequate rules made to ensure that sufficient culms are left standing in each clump. In other parts of India it has been found impossible to enforce such a practice.



General view of Nandhaur raukhar. Summer 1921.

View of the N. enclosure looking N. from the big stone on the road.



View of the S. enclosure looking S. from the same place as photo 1.



View of control plot No. 6, inside wire fence, Nandhaur raukhar. May 1921.
(Viewed S. from a N. E. peg).

UNITED PROVINCES.

I.—Experimental Silviculture.

General.—Important progress in silvicultural research has been made during the year under various heads, amongst which may be briefly mentioned :—

- (i) The study of the natural regeneration of sal (*Shorea robusta*) under a wider range of conditions.
- (ii) The study of natural and artificial regeneration of the more important timber species, notably *haldu* (*Adina cordifolia*), *sissu* (*Dalbergia Sissoo*), *bakli* (*Anogeissus latifolia*), *kanju* (*Holoptelea integrifolia*) and *teak* (*Tectona grandis*).
- (iii) The application of *taungya* cultivation on a large scale for the regeneration of forest areas. This is possibly the most important silvicultural development of the year in the Province.
- (iv) In co-operation with the Imperial Silviculturist, the compilation of a Yield Table for uniform sal crops. This was sent to the press after the close of the year.
- (v) The collection of statistical data (with a view to the ultimate compilation of Yield Tables) was carried on for several other important species.

The work carried on in the Silviculture and Research Division has followed as closely as possible the printed programme of research work. The advantages of a whole-time Research Officer, who is free to devote all his energies to pure research work, are becoming increasingly apparent, and the results of research work are having a material effect on the management of forests and the preparation of Working Plans.

Natural Regeneration.—Sal.—(a) The series of important experiments Lakhmanmandi C-4 referred to in last year's report were continued and extended. It must again be emphasised that this research is directed towards a study of the conditions of development of a seedling crop already on the ground, and not a study of requirements for getting such a crop. The results obtained during the year may be briefly summarised.

A.—In the heavily felled areas.

47 per cent. of the seedlings still survive ; of these 25 per cent. show appreciable growth of 1' or more on the average. The seedlings originally over 2' high show practically no upward growth yet. This is probably due to frequent browsing by deer or damage to the leading shoot.

B.—In the unfelled or burnt area.

25 per cent. of the seedlings still survive ; of these under 8 per cent. show any appreciable upward growth (i.e., less than 2 per cent. of the original number measured in February, 1921) while 75 per cent. have disappeared.

These results already afford an interesting comparison.

Conclusions possible from further detailed observations in the experimental regeneration areas are :—

- (1) 1921 was an abnormally dry and fierce hot weather, nevertheless after complete opening of the canopy and burning the surface the sal seedlings shot up in April and May. Drought seems no danger at all to sal seedlings that survive the first two years.
- (2) Burning resulted in a profuse natural regeneration of *haldu* on all ash heaps. Its subsequent development has been very slow, due to persistent browsing by deer.
- (3) There was a fairly severe frost in January 1923 but the high shelterwood of miscellaneous species and sal combined in each case with heavy weed and grass growth prevented all frost damage. -
- (4) Opening of the canopy and burning completely eliminated dying back in the rains, and the seedlings remain healthy even under a strong growth of weeds and grass.
- (5) On the other hand, the development of the seedlings has been seriously checked by persistent browsing by wild animals, so that the seedlings of 2' and 3' especially, which show up well, have in two years of good growing conditions made no net increase in height.
- (6) The 1913 regeneration in the unfelled and unburnt area of plot III has very largely disappeared and regeneration will have to be started again.
- (7) The 1913 regeneration in the thinned and burnt area of plot IV still persists and is by comparison with plot III fairly healthy. But over much of compartment IV of this block especially where the overwood is dense and unthinned the 1913 regeneration has very largely disappeared ; and the regeneration of this compartment will have to be started again. Probably the seedlings with 8 years of unhealthy conditions had become too weak to be helped by the burning of the last two years.

(b) A new large-scale experiment was started during the year in a hill sal area (Champagid block) of Ramnagar Division, since it is clearly recognised that results obtained in Bhabar sal forests may not necessarily be obtained in hill sal forests. Two plots of about 20 acres each have been laid together ; one plot has been heavily marked for felling leaving about 10-15 trees per acre, while the other has been lightly marked leaving about 30-40 trees per acre with a view to determine the best degree of the first opening of the crop and the subsequent treatment.

The results will be noted next year.

The Same Views in April 1928.



View of N. enclosure looking N.



View of S. enclosure looking S.



View of control plot No. 6 (Natural baldi plants).

(c) The two experimental plots (of 25 acres each) in South Kheri for studying natural and semi-artificial sal regeneration under shelterwood and strip methods gave promising results, and a fair crop of old and new seedlings are now on the ground, whose development will be carefully watched.

(d) In view of a probable bumper sal seed year in 1923, very extensive departmental burning of the leaf litter was undertaken in most of the sal divisions at the close of the year to ensure the best conditions for the seed fall. Results will be noted next year. The excellent results of early departmental burning (i.e., in March and April) are now so well established, that this easy form of assistance to natural sal regeneration will probably become a routine measure in all moist types of sal forest.

(e) Natural regeneration of sal where there is a sufficiency of established advance growth. The excellent results obtained in the Dehra Dun Division, referred to in last year's report were confirmed by equally good results in Ramnagar, Pilibhit, South Kheri and elsewhere and the system described in last year's report, i.e.,

- (1) selecting the seed trees 20-25 to the acre,
- (2) cutting everything else clean,
- (3) burning what remains of the slash after more or less complete conversion,
- (4) regenerating by coppice wherever available and elsewhere by seed ;

is now adopted wherever conditions are suitable. Summarising knowledge regarding natural regeneration of sal so far as our investigations have gone, we may say—

- (1) that burning of the leaf-litter greatly stimulates seedling regeneration (a) by reducing weeds (b) by leaving a clean floor for the germination of the seed,
- (2) that seedling regeneration will survive under moderately heavy shade for a few years, but tends to die back, and ultimately to disappear,
- (3) that a heavy felling undoubtedly checks the tendency to die back, and stimulates growth. It also greatly stimulates competitive weed growth, and the point that requires further observation and research is how long sal regeneration 1' to 3' high (i.e., not yet established) will take and to what extent it will grow up through and clear of the weeds and miscellaneous coppice shoots without rains weeding (which in our most important sal forests is not practicable). Undoubtedly deer browsing has the effect of materially lengthening this period.
- (4) that with abundant established advance growth, the regeneration of a sal area is simplicity itself, and requires

clear felling and cutting back if there is no danger of frost, and cutting back under a light shelterwood where frost damage may be expected,

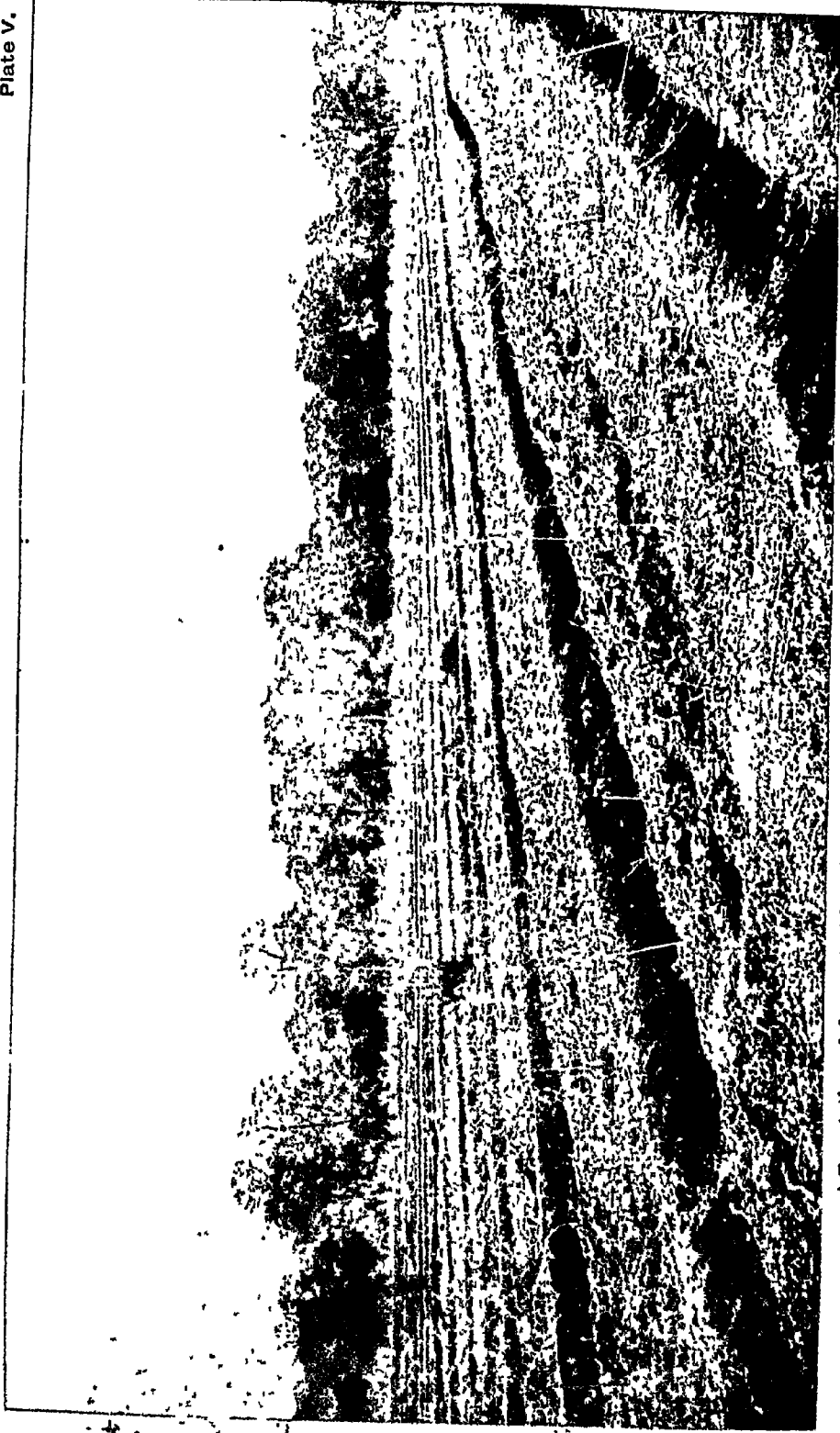
- (5) that sal seedling regeneration in any particular year or locality is largely a gamble on rain coming at the right time.

Miscellaneous Species.—(a) *Haldu*. The observations recorded last year were further confirmed, and need not be repeated. While the method of obtaining *haldu* regeneration is now well recognised, the persistent nibbling by deer almost invariably prevents the further development of the seedlings. The damage done by wild animals in areas of concentrated regeneration, of most submontane species, is becoming increasingly evident, and proposals to limit the grazing incidence by wild animals are being considered. The accompanying photographs illustrate the effect of 2 years successful protection from grazing on the natural development of *haldu*, *sissu*, *khair* (*Acacia Catechu*), etc., in the 50-acre experimental plot in the Nandhaur old river bed, referred to in last year's report.

(b) *Kanju* (*Holoptelea integrifolia*).—Four plots of 10 acres each have been laid out in Chaunsilla Compt. 3 in Ramnagar Division with the object of regenerating them with the most important miscellaneous Bhabar species, i.e., *haldu*, *kanju* and *bakli*. The results will be noted in next year's report. A somewhat similar experimental plot was laid out in the Gonda Division. In this Division, in the Tulsipur forests, we find an extensive area of mixed miscellaneous forest which appears to show an interesting example of progression of crops. Thus under an overwood of *sain* (*Terminalia tomentosa*) *bakli*, and *haldu*, we find practically no regeneration of these species at all, but in many parts a very promising crop of the more shade bearing *kanju* and in some parts, of sal. As the idea of treating a forest by shelterwood in periodic blocks, where the natural regeneration will be of different species from the trees of the shelterwood, is somewhat novel to Indian forestry, the advisability of a carefully observed experimental plot is obvious. Results obtained will be recorded in future years.

(c) *Bakli* (*Anogeissus latifolia*).—An accidental fire in an experimental garden suggested that fire had a stimulating effect on *bakli* regeneration. A number of 2-year old plants were burnt back, but the growth in the subsequent 3 months exceeded the growth in the previous 2 years. This result remains unconfirmed however.

Seed-testing and Nursery research work.—This branch of research work is left largely to the Central Research Institute at Dehra Dun. Forest nurseries are being established in most submontane divisions in the province but these are for the raising of nursery plants for afforestation and not for research. The principal species grown in these nurseries are *sissu*, teak and bamboo.



Afforestation of deserted village lands, Dolpokhra, showing soil reparation for irrigate

Artificial regeneration.—The feature of the year was the proposed or actual introduction of artificial regeneration by *taungya* cultivation. The proposal had been made before to improve the miscellaneous forests of the Kumann Bhabar by *taungya* cultivation, but the labour conditions made the proposal almost impracticable. However in the teeming and heavily populated districts of Oudh (Bahraich and Gonda) and Gorakhpur, conditions for the successful introduction of the experiment were much more hopeful. In Gorakhpur 80 acres of clear-felled sal forest which had failed to regenerate, and 150 acres of poor open miscellaneous forest were given out to cultivators, who during the 1st year cleared the land and grew their own crops, (and remarkably fine crops they obtained). During the second rains, the cultivators will sow sal or miscellaneous species and plant teak or sissu cuttings in lines, and during the second, third and fourth years will protect and tend and weed the young seedlings and plants. In one way the problem of *taungya* cultivation is considerably simpler in Oudh than elsewhere. In other Provinces it is difficult to keep the *taungya* cultivators on any particular area for more than 2 years; in Oudh and Gorakhpur the difficulty is to get them to move on after 4 or 5 years, but this is all to the advantage of a slow developing species such as sal. *Taungya* plantation work is still experimental in this Province, but it promises to give excellent results and to be widely applicable in the Eastern districts. Mr. Wood (D. F. O. Gorakhpur) has the distinction of introducing *taungya* into the Province, and the idea was enthusiastically taken up by the Divisional Forest Officers of Bahraich and Gonda. The Conservator of Forests, Working Plan and Research Circle made proposals for the gradual introduction of *taungya* cultivation over extensive areas in Bahraich (10,000 acres), Gonda (5,000 acres) and Balrampur Estate Forests (10,000 acres) where the ground has been trampled bare by uncontrolled and unlimited cattle grazing or reduced to a wilderness of impenetrable and inedible thorns and shrubs, as *taungya* appears to be the only cheap and feasible means of restoring such areas.

The artificial regeneration of sal on the Gorakhpur line has been extended to other divisions, notably, North and South Kheri, and results are very promising. But one great hindrance to artificial sal sowings is the difficulty of storing large quantities of seed until adequate rain falls. The delay in the monsoon rains was the direct cause of the failure of sal sowings in Haldwani, Ramnagar and other divisions. The small scale experiments referred to in last year's report in artificial sal regeneration in a frost area (Dolpokhra plantation) gave interesting results. The sal plants in the open were killed back to ground level in January but sent up vigorous shoots later in the year. Although it is feared will again be cut back next winter, the sal growth under a shelterwood of young sissu was not affected in any way by frost, a certain proportion died back in the hot weather, but shot up again in the rains. Further results will be noted next year.

Miscellaneous Species.—The research and experiments of the last 5 years have definitely established certain points, which may be noted :—

Haldu (Adina cordifolia).—Five years ago, the artificial or natural regeneration of this species was a sealed book. We now know that its regeneration can be assured given the necessary condition of (a) clean mineral soil completely free of weeds (b) immunity for the tiny seeds and seedling from being washed away. An intensive fire, which kills weeds and leaves a thick deposit of ash on the freely exposed soil, has usually resulted in excellent *haldu* regeneration, whether sown naturally or artificially. (A similar and very interesting occurrence has been noted in the hill forests near Ranikhet, where natural *Eucalyptus Globulus* regeneration has come up after the fires of 1921. The *Eucalyptus* seed is nearly as diminutive as *haldu* seed).

Sain (Terminalia tomentosa).—Excellent results have been obtained with this species by sowing on moist clay-loam soils and weeding in the rains. But both with *sain* and *haldu*, the further development of the young plants is terribly retarded by deer browsing.

Bakli (Anogeissus latifolia).—Experiments have shown that scarcely 1 per cent. of *best selected seed* is fertile, and to obtain any sort of a crop sowings have to be extremely dense. Development of seedlings, even when protected from grazing, is very slow, and bushy plants 2' high and 5 years old are about the average.

Teak. (Tectona grandis).—Interesting experiments with this species were carried out during the year, and the following points established :—

- (a) Sowing when the rains break results in poor or no germination.
- (b) Sowing early in April promises to give much better germination.
- (c) It is an excellent species for propagation by root and shoot cuttings.
- (d) In areas of intense demand, and free of frost, teak promises to give excellent results.

A 40-year old plantation of poor quality felled in Gorakhpur gave over Rs. 1,000 per acre revenue, which represents Rs. 25 per acre per annum since creation. Eight months after the felling, the area was covered by a most abundant crop of coppice shoots up to 18 feet in height.

The introduction of teak is being carried out on an extended scale in Banda, Gorakhpur and Gonda, Bahraich and other divisions of the Province, and experimented with in Allahabad, Ramnagar and elsewhere.

Sissu. (Dalbergia Sissoo).—The species of excellence for afforestation purposes on light soils and easily propagated by root and shoot cuttings. The accompanying photographs illustrate the



Dolpokhra *sissu* plantations, the same area in 1923, across the lines.



Dolpokhra *sissu* plantations, the same area in 1923, in the lines.

Dolpohra *sissu* plantation in April 1920 and April 1923, and the results here shown are typical of hundreds of acres created during the last few years. A few old plantations, of about 40 years old, occur in the Province, in which the growing stock is now worth Rs. 1,000 per acre standing. But to introduce *sissu* on heavy clay soils is a mistake.

Chir (*Pinus longifolia*).—Encouraged by the results obtained by the Imperial Silviculturist in the Zabarkhet tapper near Lachiwala an experiment has been taken in hand to try to convert a sal area in the Chokhamb Dun in Lansdowne Division into *chir* forest. The terrific frost in this locality renders sal useless and hopeless, and as grass growth is most vigorous and rains weeding impossible, *chir* is the only species which gives any promise of success. Results will be noted next year.

Afforestation and reclamation.—Work in the Afforestation Division continues to be uniformly successful, and out of 1,950 acres of new areas sown up during the year, 1,880 acres were completely successful. In the 10 years since the Afforestation Division was started over 9,000 acres have been successfully reclaimed and afforested, while a further 2,000 acres have been sown up with seeds since the close of the year. The organization of the Division can now deal with 2,000 acres annually and, given adequate rains, with every assurance of success. The amount of money invested by Government in this work is now (including 4 per cent. compound interest to date) nearly Rs. 7 lakhs, or about Rs. 73 per acre. The financial success of the plantations near the large towns (e.g., Agra, Cawnpore, Lucknow, etc.) is assured, while the plantations in the tangle of the Chambal and Jamna ravines are looked on more as a valuable fodder famine insurance and as an improvement to the conditions of grazing and agriculture generally rather than as financial investments. A very interesting development during the year has been the steady widening of the sphere of influence of this afforestation work. Starting with 3 plantations in 1913, the Afforestation Division has now about 25 successful plantations to supervise dotted about in the districts of Agra, Meerut, Etawah, Cawnpore, Lucknow, Jalaun and Jhansi. A large number of Zamindars, after seeing the successful results obtained, were anxious that their lands should be taken up for afforestation by Government, but financial stringency prevents any acceleration of this useful work at present. However two Zamindars have started operations on their lands at their own expense, which is a most promising sign. Experiments are in hand to test the possibility of reclaiming *usar* lands, which, if successful, will open up a further wide field of potential activity.

Mixtures and underplanting.—Interesting large scale experiments are being carried out in South Kheri Division. There are in that division over 20,000 acres of *phandars* or frost holes covered with sal shoots which have been cut back by frost for the last 40 years at least. If they could be adequately protected from frost there is

little doubt that they would develop into a sal forest. Attempts are being made to introduce fast-growing and frost-hardy species (such as *sisso*, *chir* and *Hardwickia binata*) to act as a shelterwood to the sal. It will be some years before conclusive results are obtained.

Silvicultural systems.—In place of the old and almost universal "Selection-cum-Improvement" method of 10 years ago, which was applied indiscriminately to all species and all conditions, an almost endless variety of Silvicultural system has been evolved and brought into application during the last few years, to meet the very varying conditions of growth and working. All the hill pine forests and some of the hill oak areas have been brought under a shelterwood periodic block system of management, which system (with modifications in details) is also being applied to the best of the sal forests where the demand is for large timber and regeneration must be chiefly from seedlings. In the sal forests of Gorakhpur, parts of Gonda and South Kheri, a system of clear-felling with regeneration partly by coppice and partly artificial is working very satisfactorily, and a further modification has been evolved in areas where frost damage is to be feared, of leaving a few standards per acre over the young coppice for 8-10 years until the coppice is safe.

Miscellaneous experiments.—The experimental plots laid out to study the phenomenon of twisted fibre in *chir* were largely destroyed in the 1921 fires, but Mr. Champion who had the investigation in hand had previously arrived at certain definite conclusions, and the results of his observations will shortly be published. He has shown that heredity is a definite factor in the development of twisted fibre, and as there are over 150,000 acres of twisted fibre *chir* pine in Kumaun unfit for timber production, the regeneration of this large area with a view to ensuring a straight grained crop in the future becomes an almost insuperable problem.

Experiments to eradicate lantana, *rohini* (*Mallotus philippinensis*) and other shrubs with sodium arsenite and Atlas solution were continued. There is no doubt that the original shoot is often killed by solution, but usually vigorous coppice shoots arise below the point of application of poison, which greatly vitiate the effects. Experiments are being continued to see if annual application over several years will succeed.

II.—Working Plans and Statistics.

As regards statistics, the chief work of the year was the preparation of a sal yield table in collaboration with the Imperial Silviculturist, Dehra Dun, which was sent to press after the close of the year. In the preparation and revision of sal working plans this yield table has proved and will prove invaluable. The statistical data collected for the yield table have also supplied sufficient reliable data for the compilation of sal volume tables, which the Imperial Silviculturist now has in hand, and which will prove equally valuable in the working of the United Provinces sal forests. Statistical work was

also continued and sample plots laid out in *sissu*, *kanju*, *khair* (*Acacia Catechu*), deodar and hill oaks, as follows :—

<i>Sal</i> —	13 old plots remeasured,	12 new plots laid out.	
<i>Sissu</i> —	5 ditto.	5 Ditto.	
<i>Kanju</i> —		2 Ditto.	
<i>Khair</i> —		2 Ditto.	
<i>Deodar</i> —	2 old plots remeasured,	0 Ditto.	1 and 3 temporary plots.
<i>Oak</i> —		2 Ditto.	ditto.

20 old plots, 32 new plots, and 3 temporary plots.

The total number of permanent statistical sample plots now laid out in the Province and remeasured at regular intervals by the Provincial Research Branch is as follows :—

<i>Sal</i> (<i>Shorea robusta</i>)	..	..	..	..	108
<i>Sissu</i> (<i>Dalbergia Sissoo</i>)	..	..	..	..	31
<i>Khair</i> (<i>Acacia Catechu</i>)	..	..	..	..	2
<i>Sain</i> (<i>Terminalia tomentosa</i>)	..	..	..	..	1
<i>Kanju</i> (<i>Holoptelea integrifolia</i>)	..	..	..	..	3
<i>Semel</i> (<i>Bombax malabaricum</i>)	..	..	..	..	1
<i>Jaman</i> (<i>Eugenia Jambolana</i>)	..	..	..	..	1
<i>Deodar</i> (<i>Cedrus Deodara</i>)	..	..	..	..	21
<i>Chir</i> (<i>Pinus longifolia</i>)	..	..	..	..	49
<i>Kail</i> (<i>Pinus excelsa</i>)	..	..	..	..	5
<i>Oaks</i> (<i>Quercus spp.</i>)	..	..	..	..	28
Total	..	..	..	..	250

Many additional plots laid out some years ago which were damaged by fire or proved unsatisfactory have been abandoned.

It is important to emphasise the stimulus that statistical research has received in this province since the appointment of a whole time silvicultural research officer. The first reliable statistical sample plots were laid out in 1911 by the Imperial Silviculturist, Dehra Dun, who with the research work of all India and Burma to look after, nevertheless laid out 149 plots in these provinces during the next 10 years, or an average of 15 plots a year. In the following 3 years, when the statistical work was largely taken over by the provincial research officer, 173 new plots (permanent and temporary) have been laid out and measured up and in addition 82 of the plots laid out previous to 1920 have been remeasured, giving a total of 255 plots measured and remeasured, or 85 plots a year.

During the year the Imperial Silviculturist proposed that in future statistical field work should be carried out by the provincial staff, while the central research institute would undertake to work up the figures, calculations, and office work, a proposal which was very welcome to this province, where field work had in point of fact outrun the facilities for calculating up results.

During the year an important publication entitled " Handbook of Forest Management in the United Provinces " was compiled in the Working Plan and Research Circle. The book is intended primarily to help Working Plan Officers; and illustrates by concrete examples how the theory of working plans as described in standard text books is actually applied or modified in practice, and in addition to each silvicultural system being described separately, there are chapters on working plan organization, on control, and sections on afforestation, the resin industry, fire protection, etc. The book was sent to the United Provinces Government Press after the close of the year, and its publication is expected shortly.

CHAPTER III.

BOTANY.

CENTRAL INSTITUTE.

The shortage of staff referred to last year has persisted during a great part of the year under report, and this combined with financial stringency is likely to bring the work of the branch to a close except as regards work that can be done in Dehra Dun. It was hoped to begin a field study of the species of *Dipterocarpus*, a matter which has been pending for many years, and the Systematic Botanist had arranged a 3 months' tour in Tenasserim for this purpose. After all arrangements for transport, etc., had been made the tour had to be cancelled, as owing to shortage of staff in other branches the Systematic Botanist had to be employed on work connected with the Empire Exhibition. Consequently this tour has had to be postponed, and is unlikely to take place in 1923-24 as the funds allotted under travelling allowance are insufficient for any long tour.

Oecology of Sal.—Work under this head has now reached the stage at which the Botanical Branch can leave it. The results of the small-scale experiments made by Mr. Hole during past years are being used on large-scale regeneration works by the Silviculturist of the United Provinces; and the small plots maintained hitherto by the Forest Botanist will be abandoned.

Herbarium.—The number of sheets added to the herbarium during the year is 5898, which is approximately twice the number incorporated during the previous year. The increase is due partly to the incorporation of a large collection of plants collected by Rai Bahadur Keshavani in Kashmir, which had been lying in bundles for many years, and nearly half of which were found to be insect-eaten and useless; also a similar but smaller collection left by the late Mr. J. Donald of plants from the Central Provinces. Next 866 plants of the former Saharanpur collection and nearly 2000 of Mr. Drummond's collection also received from Saharanpur were named and incorporated during the year. The final

disposal of the unnamed plants received with the Saharanpur herbarium is a work that has been long delayed but which is now nearly finished; the only portion likely to be delayed much longer is the disposal of a collection of trees and shrubs of Queensland. These Saharanpur plants had all been poisoned and consequently are in good condition. The main contributions of Indian plants were received from Mr. Hole, who presented his private herbarium, and from Messrs. R. N. Parker, B. L. Gupta and the Forest Economist.

Exchange of Herbarium Material.—The herbarium has been growing steadily during the past years at the rate of some thousands of sheets a year, mainly of N. W. Indian material, whereas plants from other parts of India and especially South India are badly represented. Efforts have therefore been made to exchange surplus material of N. W. Indian plants for plants from other parts of India, but hitherto with no success. On the other hand several valuable contributions have been received from abroad, the most valuable of which is a collection of 129 sheets mainly of Wallich's plants received from the British Museum. Previous to this none of Wallich's specimens were represented in the herbarium. Other notable contributions were received by exchange from the Forest Department, Union of South Africa, the National Herbarium, Sydney N. S. W., and the Arnold's Arboretum, United States.

One hundred and eighty-three specimens were identified for Forest Officers and others. It has been customary to quote a figure of this nature every year, but it represents only those plants regarding which official letters are written. Consequently almost all the plants identified for other branches of the Research Institute as well as those done for Forest Officers and others who bring plants with them and take away the identifications are excluded, as are also the identifications of the larger collections presented to the herbarium. A great deal of time has been spent on identifying botanical material sent in authentication of timber specimens for the Forest Economist. Over 100 of these have been done during the year, and with few exceptions these do not appear in the figure 183 quoted above.

Seventy-three consignments of seeds weighing over 512 lbs. were despatched in fulfilment of indents during the year.

Fifty-eight volumes, excluding duplicate copies and periodicals, were added to the library during the year.

Pathology.—The most interesting discovery was that the trees of *Dalbergia Sissoo* dying in considerable numbers near Dehra Dun are in all probability killed by a fungus identified in Kew as *Polyporus gilvus*. Hitherto it has always been assumed that the deaths were due to *Homos lucidus*, as the symptoms are identical, and sporophores of *Homos lucidus* have been found on *Dalbergia Sissoo* near Dehra. This year however sporophores of *Polyporus gilvus* have been found in large numbers on *Dalbergia Sissoo*, which is in no case could any sporophores of *Homos lucidus* be found on this host, though it is not uncommon on *Albizia procera*. The evidence

appears to show that in Dehra Dun the deaths of *Dalbergia Sissoo* are usually due to *Polyporus gilvus* and only exceptionally to *Fomes lucidus*. As *Polyporus gilvus* does not appear to have been recorded previously as a parasite in India inoculations of *Dalbergia Sissoo* with this fungus have been made to see if it is capable of killing healthy trees.

ASSAM.

Systematic.—Specimens of the tree “*Sundi*” in Cachar, thought to be *Phoebe attenuata*, were sent to the Imperial Forest Botanist by Mr. J. S. Owden ; it turned out to be a new species and has been named *Cinnamomum Owdeni*.

BENGAL.

No information available.

BIHAR AND ORISSA.

No information available.

UNITED PROVINCES.

No information available.

PUNJAB.

No information available.

CENTRAL PROVINCES.

No information available.

BOMBAY.

No information available.

MADRAS.

No information available.

BURMA.

No information available.

ANDAMANS.

No information available.

COORG.

No information available.

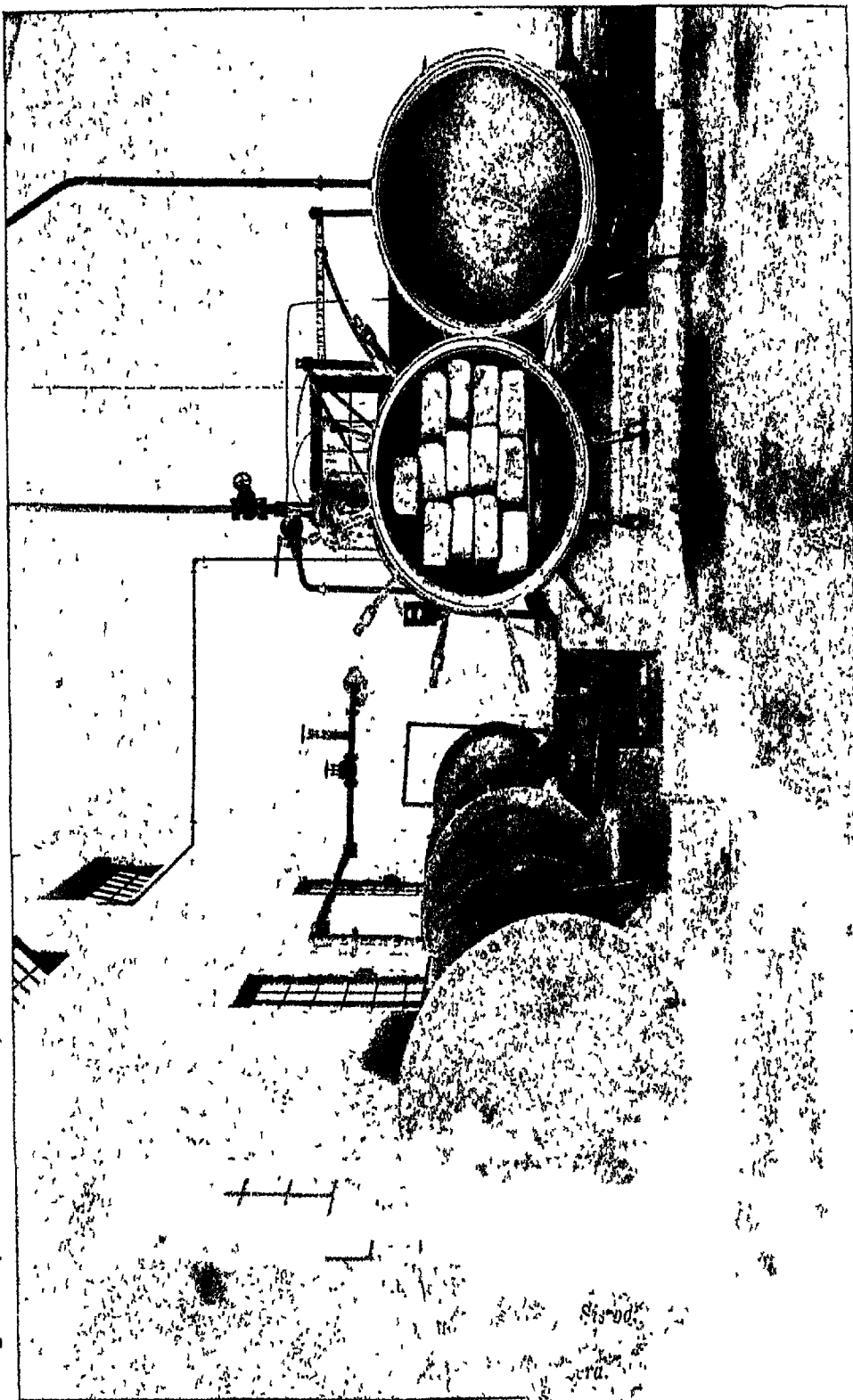
CHAPTER IV.

FOREST ECONOMY.

CENTRAL INSTITUTE.

I.—General Work & Administration.

1923 has been a year of rapid expansion on the lines of the year's report and although the activities of the Branch have been curtailed owing to financial stringency, the work has been satisfactory.



The Forest Economist was absent on leave for six months during the year and Mr. W. A. Robertson took over charge of the Branch in addition to his own duties in the Minor Forest Products Section. On the return of Mr. Pearson, Mr. Robertson himself went on leave; and as no officer was delegated to take charge of the Minor Forest Products Section it was decided to close down this section for the time being; and so far as can be seen at present it is not considered likely that the post will be filled for some little time. The Forest Economist had the major portion of his time taken up in organising and controlling the erection of the plant at the New Site; and at the close of the year under review, the Sawmill, Wood Preservation Plant and Seasoning Kilns were practically completed; the Paper-Pulp Plant and the Veneer Section were well on their way to completion; while some of the Timber-Testing Machines were erected and others working in a temporary workshop. This erection work has naturally taken up a great deal of the various Sectional Officers' time; but this has not prevented them from carrying on their work at the old Institute, detailed accounts of which are included in this report. It is satisfactory to note that the installation of the plant has proceeded without a hitch owing to the untiring interest shown by Sectional Officers in their respective charges, and by the Imperial Works Officers who are responsible for the actual setting up of the machines.

The financial condition of the country has reacted, as everywhere, on the Economic Branch, and although much has been done, there is no doubt that had Imperial and Upper Grade Assistants been appointed to the Sectional Officers, to be trained under their expert supervision, the results would have been considerably better. The whole staff has worked most loyally during the year, as the results mentioned hereafter will testify.

The Forest Economist's touring was restricted, due to the continual supervision work at Dehra, to a visit to Calcutta in connection with the Exhibition of 1924; and to inspecting some experimental sleepers near Hardwar. Mr. Jollye, who held the appointment of Assistant Forest Economist until October 1922, when he went on leave and was replaced by Mr. Trotter, inspected the experimental sleepers on the Itarsi-Betul Section.

Year by year the number of enquiries increases, both from Forest Officers, the Railways, Ordnance and Army Departments, Public Works, commercial firms and private persons; so that the position now is that the staff, as at present constituted, cannot adequately cope with the work. When the Imperial and Upper Grade Assistants have been appointed, and the new laboratories and workshops are in full running order, this difficulty should be overcome.

The Imperial Forest Station, which was started last year, has proved to be a most valuable addition. It has now been enlarged and developed.

II.—*Experimental and Commercial Activities*

1. *Section of Wood Technology.*

The Wood Technologist, Dr. H. P. Brown, who came to the Institute for 22 months from Syracuse University just before the commencement of the year under report, has laid a fine foundation to the work of this section, which may be divided into two heads; namely, routine and research work. Under routine work may be mentioned the identification of timbers. We receive constantly specimens of timbers for identification, either in connection with a special enquiry from the provinces, or from commercial concerns, the railways and not infrequently for legal cases. The other portion of routine work consists in consulting with the other specialists on the staff as to properties of woods for a stated purpose, which are best determined from their anatomical structure.

The research work in hand comprises :—

I.—The preparation of keys for the determination of timber specimens in the field based on microscopical features, as seen under a pocket lens.

II.—The same, based on microscopical characters for critical determination in the laboratory.

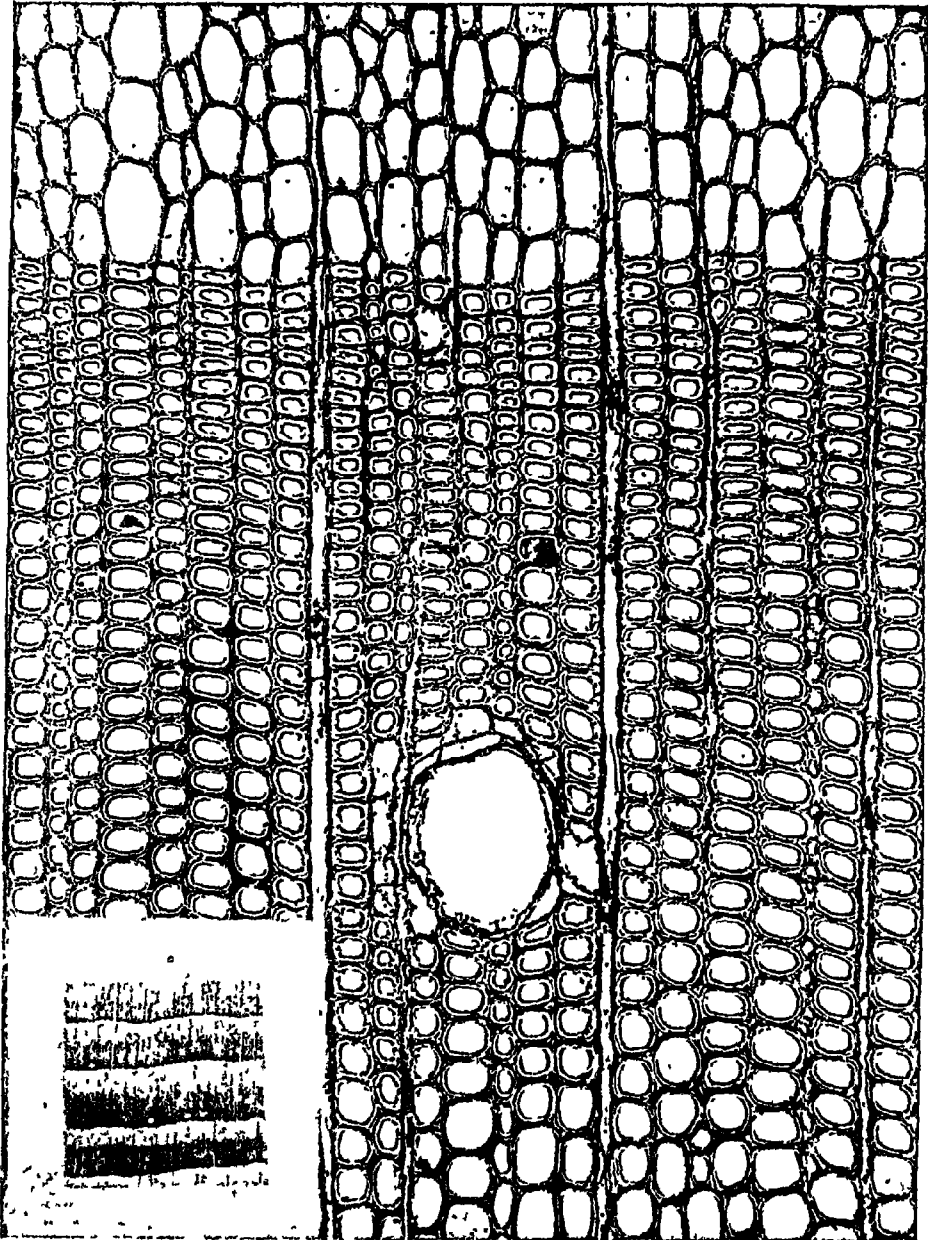
III.—The preparation of a syllabus for use in teaching wood anatomy to the Provincial Class students.

The progress made is that the routine work has been kept up to date. On the research side mounts for microscopical work and photo-micrographs have been prepared for approximately 175 species of timber. These latter consist of cross, tangential and radial microsections, of which photographs have been prepared for all the cross sections and 60 of the tangential sections at a 380 magnification. Another 125 species are in preparation for sectioning. No "low power" sections have as yet been prepared, but this side of the work will be started as soon as the hot weather begins, when photography will be held temporarily in abeyance till the rains break.

2. *Section of Timber Seasoning.*

The buildings for the experimental seasoning kilns at the new site have been practically completed, and the installation of the mechanical equipment has progressed to such a point that the kilns are ready to operate if steam and water are available.

The experiments which had been under way for three years in connection with the air-seasoning of 53 important species of timber in different parts of India, have been concluded, and the results, have been published in "Indian Fore Records, Volume IX, Part V." "Further Experiments in the Air-Seasoning of Indian Timbers and General Reconstructions of the Air-Seasoning Methods," by Mr. G. A. Sweet, and "Damage to timber by air-seasoning," with a chapter on "Air-Seasoning," by Dr. C. F. C. Beeson.



A specimen microphotograph and macrophotograph (inset) of *Pinus Merkusii*.
(Similar photographs are being prepared for most of the commercial timbers of India,
and will be published in due course together with keys for identification.)

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An air-seasoning experiment on a commercial scale has been started in the Government Agent's timber depot in Calcutta, with eight important timbers from Bengal and the Andamans, to determine (a) the length of time required for the air-seasoning of various timbers under moist climate conditions and (b) the amount of depreciation due to cracking, splitting, staining, etc. Definite figures as to these items are totally lacking for Indian timbers, but are of primary importance in determining the relative economy of kiln and air-seasoning. Figures pertaining to kiln-seasoning will be accumulated at Dehra Dun when the experimental kilns are in operation.

A comprehensive scheme has been outlined by Mr. C. V. Sweet, Officer in Charge Seasoning, and experiments initiated, to determine for the Government Gun Carriage Factory at Jubbulpore the most economical procedure to follow in the seasoning of their timber. The experiments are being carried out with the object of determining to what extent their present practice may be improved either by remodelling their present timber-seasoning godowns or by installing seasoning-kilns. Figures are being accumulated to show which method of seasoning is most economical. The work at Jubbulpore affords an opportunity to accumulate data which can be got in no other way, and which will be of general value to the Institute. As a part of the general scheme a shipment of 3½" sissoo (*Dalbergia Sissoo*) planks and felloes was sent to Dehra Dun for kiln-seasoning. The timber was kiln-seasoned in two months time to a point of equilibrium with the dry climatic conditions of the Central Provinces with practically no loss whatever from cracking, splitting, etc. In the past similar timber has been air-seasoned at the Gun Carriage Factory from 4 to 5 years according to the present system, and there has been considerable loss at the end of that time due to splitting. The very marked reduction in the seasoning time by kiln-seasoning will reduce the Factory's capital outlay in timber by lakhs of rupees.

Detailed assistance in the way of specifications and instructions have been given to two well known timber firms. Upon invitation the Officer in Charge Seasoning spent two days at each plant, and after studying their respective seasoning problems in detail gave opinions and recommendations as to the proper methods of seasoning the timber. In one case seasoning-kilns had already been installed, and the assistance pertained to alterations and improved methods of operation. In the other case the company was interested in installing a seasoning-kiln and required detailed specifications for construction. In both cases considerable office work was involved in the preparation of reports and recommendations to the companies interested.

An illustrated lecture on the importance and the economic value of timber-seasoning was given by the Seasoning Officer in the Indian Museum, Calcutta, under the auspices of the Gal. Chamber of Commerce and Director of Industries. The timber firms of Calcutta

were well represented at the lecture, and it is thought that the occasion served to awaken considerable interest in the work that is being started at Dehra Dun along this line.

Probably the most important factor governing the introduction of new species of Indian timbers into the market is the question of proper seasoning and grading. The suppliers and users of timber are reluctantly being forced to recognise the importance of adopting correct methods of seasoning their timbers, by repeated failure and loss in trade ; this being the case it is imperative that this section of our work be developed to the utmost. It is satisfactory to note therefore that this section has done most excellent work throughout the year, and that we are now well on the way to tackling the most important of all utilization problems, namely, the proper seasoning of timbers in India.

The Seasoning Officer went to Rangoon to confer with the Seasoning Officer in Burma regarding the co-ordination of work and particularly the adoption of uniform grading rules to be used in judging the results of seasoning experiments.

3. Section of Timber Testing.

The four testing machines erected in the temporary workshops were in operation throughout the year, and the work according to project 1, which was prepared and sanctioned last year was taken up. Project No. O, which comprises all special enquiries, such as spike-pulling tests on sleeper woods, impact and static bending tests on tool handles, etc., was also in force, and valuable data accumulated bearing on the various subjects. The foundations for all machines were put into the new testing shops, and two machines erected. As soon as the electrical scheme is put through the machines now in the temporary workshops will be taken down and re-erected at the new site.

The importance of timber testing may be gauged by enquiries made by persons and bodies with widely different interests and spheres of action. Thus Mr. Seaman, Officer in Charge, Timber Testing, was entrusted with the work of rewriting the portion pertaining to timber in the Military Works Handbook, and submitted a list of grading rules and tables of working stresses to the Punjab Public Works Department. Similar information was supplied to the Superintendent of Workshops, Sarda Canal ; to the State Engineer Mayurbhanj ; to the Bridge Department, Great Indian Peninsula Railway ; and to the Executive Engineer, Saharanpur. Tests were carried out to determine the best size hole to bore *pyralis* sleepers (*Xylia valatilis formis*) for spike-driving on behalf of the Burma Railways ; while bending tests on bamboo lance-shafts were carried out for the Inspector of Guns and Rifles, Ishapur. A long series of tests were carried out to find substitutes for hickory for oil-well sucker-rod and definite and satisfactory results obtained and submitted to the Oil Companies concerned. Tests on hammer-handles

were carried out for the Government Wood Working Institute, Bareilly, and a further supply of new timbers has been received with a request that similar tests be carried out. A number of reports were prepared, the most important of which is an Interim Report on all results obtained under Projects No. 1 and No. O, which is now in the press.

The total number of tests carried out during the year was as follows :—

	Mechanical.	Physical.	Total.
Project No. O	3012	1801	4816
Project No. 1	2795	3667	6462
Total	5807	5471	11278

Routine tests according to Project No. 1, involving tests on green, air-dried and kiln-dried, specimens, were carried out on teak from Burma and the Central Provinces, on *sain* (*Terminalia tomentosa*), *kanyin* (*Dipterocarpus alatus*) *gurjan* (*Dipterocarpus turbinatus*) in (*Dipterocarpus tuberculatus*), *deodar* (*Cedrus Libani* Var. *P. adara*) and tests on green material only on *bakli* (*Anogeissus latifolia*).

Tests according to Project No. O comprised :—

1. The completion of preliminary tests on sucker-rods.
2. The completion of preliminary tests on Stent concrete sleeper plugs.
3. A series of spike-pulling tests on railway sleepers.
4. Impact tests on hammer and implement handles.
5. Comparative tests along routine lines of *Frenela rhomboidea*, *Eucalyptus Globulus*, *Cullenia excelsa*, *Cupressus torulosa*, *Kaya assamica*, *Lagerstroemia tomentosa*, *Pentace barmanica*, *Cupressus macrocarpa* and *Cryptomeria japonica*.

During the year a new type of spike-pulling meter and a modified type of compressometer were designed by the Timber Testing Officer. The former has only been calibrated and not yet tested, while the latter after calibration has been put in use and found to be most satisfactory.

4. Section of Minor Forest Products.

Mr. Robertson took over charge from the Forest Economist in May, and held charge of the major office in addition to his own duties during the 8 months that Mr. Pearson was on leave. This double charge entailed such heavy work that all serious research work in connection with Minor Forest Products had to be abandoned. Mr. Robertson himself proceeded on leave soon after Mr. Pearson's return to duty.

The scheme to establish an industry in *Boswellia serrata* gum oleo-resin in the Bombay Presidency is still under consideration, and the work in this connection is being actively prosecuted. The up-to-date steam distillation plant for producing "Rosha oil" from *Cymbophogon Martinii* grass in the Central Provinces, which was erected 2 or 3 years ago has proved a success and may now be considered an established fact. It is to be hoped that the appointment of an officer to take charge of the office of Minor Forest Products will not be indefinitely postponed, as a richer field for enquiry and one more likely to yield sound commercial results, would be difficult to find.

5. Section of Wood Utilization.

Owing to the seasoning-kilns, wood workshops and testing laboratories not being in full working order, and the veneer plant not being erected, the number of experiments carried out was restricted to those which could be dealt with in the existing testing laboratories and by sending the timber elsewhere to be dealt with. The rough-cut specimens to be tested for bobbins by a large manufacturing firm in England, have been reported on, and generally speaking the results are not encouraging. The report however, has not yet been fully considered, as it has only been recently received. The tests carried out to find woods suitable for sucker-rods definitely showed that *Terminalia tomentosa* and *Heritiera minor* can be used as substitutes for hickory. Much interest has been taken and a large number of enquiries received in connection with match-making, owing to the high import duty now imposed on foreign matches. Most of our Indian timbers which have been tried have proved to yield poor quality splints. It is possible that better results may be obtained with these woods by using a slicing instead of rotary machine. Until we can get our Seasoning, Timber Testing, Wood Technology, Wood Preservation and Veneer Sections going and be given an adequate staff, we shall not be in a position to solve the various problems before us and give the best advice to the many enquiries.

6. Section of Wood Preservation.

The work of years at this subject is now bearing fruit, as the railways have accepted the use of treated sleepers, while some systems have put up treating plants and others are actively engaged in schemes to do so. The North-Western Railway is treating large quantities of sleepers with creosote in open tanks, and has erected a large pressure plant, which should soon be in operation. The Assam Railway Trading Company has also erected a pressure plant; sleepers are being treated in open tanks in Southern India, while several other railways have projects on hand to treat their sleepers themselves.

There remains a very important side to this enquiry which has still to be undertaken, and that is to carry out absorption

tests, and to determine the most economic method of treating the many species of Indian timbers mechanically suitable but deficient in durability unless treated for sleeper work. The experimental pressure plant, purchased some years ago by the Forest Research Institute has now been erected, tested and found to answer the purpose admirably. It is so designed that timber can be treated by all well-known methods except the Card process. The difficulty is that due to financial stringency no Wood Preservation Officer has been appointed, though the results which could be obtained even in a short period of time would certainly be out of all proportion in value to such an officer's salary. In the mean time, provided an assistant can be appointed, the Forest Economist hopes to run through a little of the most urgent work himself.

Two records of experiments covering a period of over 10 years were issued during the year : the first, Indian Forest Record Volume IX, part 1, 1922, "Results of the Antiseptic Treatment of Sleepers" and the other, Technical Paper No. 231 published by the Railway Board, entitled "Antiseptic Treatment of Sleepers in India" both reports being by the Forest Economist.

7. Section of Paper Pulp.

Mr. W. Raitt was in charge of this section throughout the year, and was chiefly engaged on supervising the erection of the complicated experimental pulp plant, with a digester of approximately 15 cwt. capacity and an up-to-date 36" experimental paper machine. The necessary crushing and chopping machines are also being installed. The plant is now practically erected, with the exception of the water and steam connections.

At the request of the Bihar and Orissa Government the Officer in Charge Paper Pulp visited the Cuttack and Angul forests with a view to determining the feasibility of starting a bamboo pulp scheme in that locality. The subject was carefully worked out and a detailed report submitted to the Local Government, which indicates a promising commercial proposition. At the request of the Sirmur Durbar a local enquiry was made into the pulp-making resources of the State, and a report presented to the Durbar.

A considerable amount of laboratory work was carried out in connection with bamboo and grasses, which will be of great value when large-scale experiments are started with the new experimental plant. A number of routine enquiries were dealt with during the year.

8. Section of Tans.

Mr. Pilgrim, Officer in Charge Tans, was in charge throughout the year, and was stationed at Mergui in Lower Burma to carry out an exhaustive enquiry into tan-stuff of the mangrove forests of that locality. He has now completed the work and is engaged in writing

up his report. He also completed a valuable report on the myrobalans of the Central Provinces and *Terminalias* of Burma, which has now gone to press. He has also issued a pamphlet during the year on the tanning properties of certain *Lagerstroemia* in Burma, which appeared in the "Indian Forests."

The Tan section is now to be closed, as due to the slump in the trade and to the more important fields of enquiry with respect to raw material having been worked out, the funds available for research can be utilised to better advantage in other directions. Before Mr. Pilgrim severs his connection with this branch of the Institute the Forest Economist would like to record the unfailing zeal and ability with which Mr. Pilgrim has worked and prosecuted his enquiries, often in very uncongenial localities.

9. Sub-Section of Wood Working.

During the year under review a total of 483 general orders were executed for all branches of the Institute. 4700 specimen tests pieces were prepared for the Officer in Charge. Timber Testing, and 3000 specimens of various timbers were handed over for distribution as hand specimens for exhibition in the museums or for other purposes. In addition to the above this Sub-Section has done a considerable amount of work in connection with the New Site having built the log-roll, track-stringer and carriage for the new sawmill and covered in the trenches of both the sawmill and wood preservation plant. The seasoning-kiln doors were also made and fitted by this sub-section, a difficult piece of work as the doors have to be made air-tight and so constructed that they do not warp when subjected to artificial heat on one side and atmospheric temperature on the other.

Of the orders executed the following items will give some idea of the work turned out.

1. F. Economist, Head Office, Museum, etc.—

Filing cabinets, stationery cases, motor lorry and Army Transport wagon in 3-ply (experimental), type cases, desks, veneers for forest bulletins, show cases, hand specimens, and telephone box in *padank* and 3-ply panelling.

2. Wood Technologist—

Laboratory fittings, tables, almirahs, staining sinks, stools, book-cases, and designing and construction of special dark room.

3. Timber Testing.—

4,700 test specimens prepared, filing cabinets, card index cases, desks, stools, battery boxes, instrument cases, etc.

4. Seasoning.—

Baffle boxes for new seasoning-kilns, kiln doors, and frames.

for seasoning experiments, and desks in *kokko* (*Albizia Lebbek*) with *sain* (*Terminalia tomentosa*) panels.

5. Paper Pulp.—

Desk.

6. Forest Entomologist.—

Cabinet stands, card clips, almirahs altered, almirahs supplied, packing cases, insect boxes, plinths, chisel handles, etc.

7. Silviculturist.—

Index card cases, negative boxes, almirahs altered, callipers, filing cabinets, tent poles, dark room fittings, and a specially designed frame for exposing blue prints.

8. Forest Chemist.—

Pedestal, almirahs, card index boxes, etc.

9. Central Library.—

Almirahs and book cases made and supplied.

10. Electrical Engineer.—

Trolleys made to carry electric plant at the New Site.

11. Sports Committee.—

Parallel bars for the provincial students and hurdles for the annual sports.

All the above articles were supplied free of cost or at cost price to the offices mentioned, and it is estimated after careful checking that this cost works out to about 50 per cent. less than when the same work is given to local contractors. This in itself is a very great saving to all the offices of the Research Institute, not to mention the quality of the work, which is first class.

ASSAM.

Wood Preservation.—A plant for the antiseptic treatment of sleepers has been erected at Margherija by the Assam Railways and Trading Company, and is now working successfully. The cylinders will take about 500 M. G. sleepers at one time, and as the time for treatment occupies 4 hours, the Company expects to be able to treat 1,000 a day, or allowing for 250 full working days in the year, 2,50,000 per annum. At present they are using oil only, on account of the high price and difficulty in procuring creosote, and it is doubtful whether this will be so efficient preservative.

The experimental sleepers at Mariani were inspected with the Assistant Engineer, Mariani, just after the close of the year. *Hollong* and *Hollock* have on the whole done well to date.

The following table of percentage of removal will be of interest.

Species.	When laid in line.	Per cent. of failure.
Hollong . .	November 15	4.7
Hollock . .	November 15	nil.
Hollong . .	December 15	8.4
Hollock . .	December 15	12.3
Hollong . .	December 16	10.2
Hollock . .	December 16	6.2

As was remarked last year *Otenga* has also done well, of 31 treated sleepers laid down in November 1915, only 3 have been removed to date or 9.6 per cent.

Minor Products.—These were fully reviewed by Mr. Todd last year, and there have been no changes.

Wood Working.—A new 3-ply plant is in course of erection by the Assam Railways and Trading Company, at Margherita.

Miscellaneous.—The following note is from the report of the Divisional Forest Officer, Sib-sagar.—

I examined 3 of the experimentally treated *sasi Aquilaria Agollacha* trees in the old *sasi* Plantation and sent three samples to Dehra Dun for examination. The following is a copy of the note sent with the specimens :—

“ *Agar Plantation Experiment trees, March 9, 1923.*

“ *Tree No. 29* which had previously been inoculated with Agar and plugged in three places. A section including one of these three places was cut off the trees. What appears to be a clear trace of infection above and below the hole was visible showing the early stages of ‘doom’ formation.

Tree No. 22 as above but unplugged.—This tree had been attacked by white ants, possibly due to the absence of the plugging peg. There were traces of infection but not nearly so marked as in No. 29.

Tree No. 31 (also unplugged) was felled and the whole section including the 3 bore holes removed. What appears to be clear indications of infection and also of the presence of independent agar in the centre of the tree will be seen.

With regard to Mr. Smythies’ report regarding resin and turpentine in the Aka Hills, it was found that the cost of extraction would be too high to allow of a profitable return.

BENGAL.

Utilization.

The report of last year detailed the scheme and aims of the work at Sukna in the Kurseong Division and concluded with proposals for this year's working.

The Sawmill.—Softwood sawing was commenced as soon as logs were brought in from the coupes in November, with the mill running on the original layout. The stores ordered from America did not arrive till February, but their installation, especially the inserted-teeth main-saw, the gang-edger, sawdust-conveyor and Marvello water-elevator, have all proved satisfactory. The crew of the mill has been reduced and a higher output of better quality planking was obtained at a reduced cost. The advantages of inserted teeth saws for small forest mills have here been fully demonstrated.

From November till the end of March, 13,640 c. ft. of softwood logs were sawn into $\frac{1}{2}$ -in. planking and corner pieces for tea boxes, yielding 1,61,480 s. ft. planking and 1200 c. ft. timber, showing a wastage of 41 per cent. which is a satisfactory figure seeing that the mill is engaged on turning out $\frac{1}{2}$ -in. stock. The mill is capable of sawing 36,000 s. ft. in a month of 24 working days; and with the present layout and crew it enables a profit of Rs. 5 per 1000 s. ft. to be obtained (over and above royalty charges) when the selling price is Rs. 41 per 1000 s. ft. The need for labour in restocking the cleared area made it desirable to close the mill in April and May (after the softwood supply was finished). When the rains commenced, the mill was turned on to sawing sal logs from the coupe, and satisfactory results are being obtained from this work. The mill turns out between 30 and 45 c. ft. (say, 1 to 1.5 tons) of hardwood a day at a labour cost of 3 as. 4 pies per c. ft. compared with 10 as. per c. ft. for handsawing; also a saving in railway freight is effected by shipping sawn stock instead of round logs to the Siliguri sale depot. The mill will be kept running on sal logs until softwood logs from next year's coupe are ready for conversion in November or December.

Skidder.—The engine used for skidding in and loading on railway cars the logs from the 34-acre coupe did not commence work until the middle of February. A 60-ft. high lead and certain small logging stores from America enabled the work to proceed more satisfactorily than in previous years, but the time lost in man-hauling the main cable out to the distant logs made it imperative to provide some mechanical haulage. A crude rehaul drum with clutch was made and fixed to the engine; and with 2000 ft. of rehaul cable it was possible to haul out the main cable 300 yards in 3 to 5 minutes, compared with the previous time of half an hour by a gang of 6 to 8 coolies. This addition speeded up the work and enabled the coupe to be cleared in 24 months, in time for plantation work; 34,000 c. ft. of logs (1050 tons) were skidded to the railway head—roughly 15 tons a day by a crew of 7 men (1 engine driver, 2 water carriers,

3 choker men and 1 unhooker). The heaviest log skidded was 32 ft. long and weighed just over 3 tons. This old engine has shewn the advantages of mechanical extraction in these sal forests, and a new Willamette 2-drum skidder has been ordered for the 1923-24 season.

A privately-owned American circular mill commenced sawing sal under contract for the Department at the Siliguri log Depot in December 1922; until experience had been gained, the results did not appear satisfactory, but the output has been gradually increased from 10-15 c. ft. a day up to 40 to 55 c. ft. The latter figure is probably the limit with the underpowered engine installed; but with a 40 to 50 H. P. engine, it could doubtless be increased to 100 c. ft. per working day. English inserted-teeth saws by Spear and Jackson have given as satisfactory results in sawing sal here as the Atkins (American) saws have at the Sukna mill.

BIHAR AND ORISSA.

I.—General Work of Administration.

As in the case of silvicultural research experimental work in Forest Economy was left entirely to the initiative of Divisional Officers, with the exception of a particular survey which was carried out by the Provincial Silviculturist in Palaman Division for the object of ascertaining what steps should be taken to stimulate the departmental cultivation of lac.

II.—Experimental and Commercial Activities.

Minor Forest Products.—Lac. The Provincial Silviculturist studied the system of departmental cultivation of lac carried out in Damoh division in the Central Provinces, and at the close of the year was engaged in drawing up proposals for the extension of lac cultivation on a large scale in Palaman district. Lac is one of the most important forest products of India, and Bihar and Orissa supplies more than half of the whole crop. It is evident that the possibilities of its cultivation on a commercial scale are very great, and that if cultivation is taken up departmentally in all the lac-growing districts the forest revenue will be enormously expanded. In Palaman the line on which the investigation was carried out was to examine the possibilities not only of propagating lac on existing trees but of establishing plantations of lac-bearing species for concentrated lac cultivation. It has been calculated that such plantations at present market prices will yield 20 to 25 per cent. interest; and apart from their value as sources of brood lac to private cultivators they should be a very highly profitable commercial investment. For plantation purposes, *Acacia Catechu* and *Zizyphus xylopyra* are considered the species of most promise, especially the former.

Sterculia urans.—The tapping experiments in Angul Division described in last year's report were continued. Further observations show :—

- (1) The maximum yield of gum is given between the months of June and December.
- (2) Collection at intervals of 5 days, refreshing the strips at the same time, gives the greatest quantity of gum.
- (3) Gum exuded during the rains is dark brown or black in colour, while in the rest of the year it is clear.
- (4) Unrefreshed strips heal up in one to three months time, when exudation of gum completely ceases.
- (5) Pollarded or misshapen trees give a much greater yield of gum than straight healthy trees.
- (6) The average yield in gum of 45 trees during the year was one seer per tree.

Miscellaneous.—The experiments in charcoal manufacture in Sambalpur Division which were initiated two years ago were continued in the year under report ; and commercial contracts for supplying about 30,000 maunds of charcoal were carried out. In elaboration of the information given in the report for 1920-21 it may be mentioned that a standard paraboloidal kiln of a height of 6 feet and diameter 16 feet is now in use. No water of any kind is used in the preparation of the kiln covering or in any stage of the manufacture. The health of labour engaged in burning the kilns has been good, and no interchange of tasks was found necessary as was the case when the work was first initiated. Female labour has been found superior to male for the work of building and opening kilns, but inferior for the work of burning. The average cost of manufacture has been reduced to 5 annas per maund. It is hoped that by next year it will be possible to give fairly complete figures of percentages of outturn by volume and weight. The department is making an excellent profit on its commercial contracts for charcoal ; and as the demand for good quality charcoal is very large it is proposed to extend the scope of the present operations and organize the work on sound permanent lines.

COHOMBAY.

Experimental and Commercial Activities.

Minor Forest Products.

Gum from kandol (Sterculia urans).—The experiment started on 1st October 1921 to determine the quantity of gum yielded by kandol (*Sterculia urans*) was continued during the year till 31st May 1922.

The original idea was to carry it out for a period of 12 months but it was discontinued from 1st June as exudation practically stopped after the 31st of May and it was deemed useless to do any collection of gum during the monsoon months of heavy rain-fall.

Two methods were tried. In the first instance light wounds were made in the bark with a small hand-axe all round the stem about 12 inches apart up to a height of 4 feet from the ground ; and in the second case 2 shallow notches were made right at the base, one foot square and on opposite sides. The average quantity of gum per tree for the period of 8 months was 13 tolas under the first method and 17½ tolas under the second. The experiment also showed that the greatest exudation took place during the months of October to January, the average yield per tree during that period being 9½ tolas under the first method and 14 tolas under the second. It would, therefore, seem that for commercial purposes tapping would not pay during the summer months. The gum was collected every fortnight commencing from 15th October and the wounds and notches were freshened at the time of each collection. There was practically no injury to the trees under the 1st method and in the second case occlusion was fairly rapid.

Miscellaneous.

Percentage of charcoal by weight to quantity of wood used.—An experiment was carried out during the year to find out the percentage of charcoal by weight to quantity of wood used.

Measurements were taken in 6 coupes of Kalyan and Vada Ranges with the following results :—

Serial No. of kiln.	Felling Series.	Quantity of wood in maunds.	Yield of charcoal in maunds.	Percentage.	REMARKS.
1	54	605	91	15.01	Partially dry mixed wood including teak.
2	56	371½	67	17.80	Partially dry mixed wood with a good proportion of ain (<i>Terminalia tomentosa</i>).
3	69	621	114	18.35	Mixed wood with a fair proportion of hard woods.
4	69	600	132	22.00	Mixed hard woods such as ain, dhauda (<i>Anogeissus latifolia</i>), etc.
5	79	264	38	14.39	Mostly soft woods with nearly 50% teak.
6	79	300	53	17.66	Ditto.
7	80	564	73	12.91	Ditto.

Serial No. of kiln.	Felling Series.	Quantity of wood in maunds.	Yield of charcoal in maunds.	Percentage.	REMARKS.
8	80	914	187	20.45	Mixed hard woods such as <i>ain dhuwa</i> , etc.
9	82	408	60	14.70	Soft woods with about 50% teak.
Averages		527.7	90.5	17.14	

NOTE.—Maund equals 28 lbs.

The average yield was 17.14 per cent. by weight, the maximum being 22 per cent. and the minimum 12.94. As the market for charcoal was rather brisk and that for firewood dull, there was a greater tendency to burn teak firewood into charcoal than in any previous year; and in the case of kilns with less than 15 per cent. yield about half the wood used was teak. A fair yield of charcoal in other parts of India is usually put down at 20 to 30 per cent. by weight; and the experiment suggests that the method adopted in this district is not very satisfactory, and some improvement in this direction would be to the advantage of both Government and contractors.

BURMA.

I.—General Work of Administration.

The proposed Timber Research Division referred to in last year's report was not sanctioned; but after the close of the year orders of the Government of Burma (Ministry of Forests) were obtained on the improvements to the Sale Depot at Rangoon and to the Timber Economics Branch of the Research Institute. Mr. L. V. Teesdale, Timber Seasoning Expert, was in charge of the research experiments throughout the year and a suitable staff on the temporary establishment was sanctioned to assist him in his work.

II.—Activities during the year under report.

The following is a summary of various works undertaken at the Depot:—

(i) *Sawmill.*—The sawmill was kept in operation throughout the year on sawing timber for the British Empire Exhibition, for the dry kiln, for air-seasoning experiments, for shipment and for departmental use. Difficulty was experienced in keeping the mill in operation owing to the delay in the receipt of saw-teeth ordered from America, which were not delivered till August 1922. Consequently the mill saw was not run during June and July, but it was possible to break up some poor quality teak logs, and the shingle machine was put into working order to convert these into shingles.

Mr. Watson reports that the main saw is an unsatisfactory machine at best, and is only built to deal with small logs much softer than those usually met with in Burma. This saw never at any time since it was installed has done good work. It has been made to work far beyond its capacity and cannot be expected to operate, even as inefficiently as it has done, much longer.

(ii) *Dry Kilns*.—A second-hand loco. type boiler was purchased to provide steam for the dry kiln, the existing boiler being unable to raise steam for more than one kiln, and being also wasteful of fuel. The newly purchased boiler was installed on an adequate foundation and a house built to accommodate it and its fuel supply. The work was completed late in the year under report and consequently it was not possible to measure the increased economy of fuel and increased steam supply.

(iii) *Seasoning*.—The logs from which Exhibition timbers are being cut have supplied material for seasoning experiments covering a very wide variety of species. Unfortunately only a small quantity of each species has been available and in consequence it has been impossible to conduct enough experiments in each species to obtain conclusive data. However, it has been possible to form some idea of the characteristics of the species under test which may be used for guidance until more reliable data can be obtained. Experiments have been carried out with the following species:—

Teak	..	<i>Tectona grandis</i> .
In (Eng.)	..	<i>Dipteracarpus tuberculatus</i> .
Thitya	..	<i>Shorea obtusa</i> .
Thingan	..	<i>Hopea odorata</i> .
Kaungmu	..	<i>Parashorea stellata</i> .
Padauk	..	<i>Pterocarpus macrocarpus</i> .
Thitka	..	<i>Pentace burmanica</i> .
Thitkado	..	<i>Cedrela Toona</i> .
Nabe	..	<i>Odina Wodier</i> .
Yindaik	..	<i>Dalbergia cultrata</i> .
Tamalon	..	<i>Dalbergia Oliveri</i> .
Zinbyun	..	<i>Dillenia pentagyna</i> .
Mukhauwa	..	<i>Carallia lucida</i> .
Taukkyan	..	<i>Terminalia tomentosa</i> .
Banbwe	..	<i>Caraya arborea</i> .
Pyinma	..	<i>Lagerstroemia Flor-Reginae</i> .
Leza	..	<i>Lagerstroemia tomentosa</i> .
Ikaw	..	<i>Adina cordifolia</i> .
Bunga	..	<i>Stephogyne diversifolia</i> .
Yamane	..	<i>Gmelina arborea</i> .
Thitsho	..	<i>Pongamia pinnata</i> .
Thitsi	..	<i>Melanorrhoea usitata</i> .

<i>Didu</i>	(1014)	<i>Bombax insigne.</i>
<i>Thitpyu</i>	..	<i>Albizzia odoratissima.</i>
<i>Letpan</i>	..	<i>Bombax malabaricum.</i>
<i>Thabybyu</i>	..	<i>Eugenia Jambolana.</i>
<i>Sit</i>	(1014)	<i>Albizzia procera.</i>
<i>Kusam</i>	..	<i>Hymenodictyon.</i>

The results have been very much better than was anticipated and it would appear that practically all of these indigenous species can be successfully seasoned artificially, and most of them when intelligently handled, may be seasoned successfully by natural methods. *Taukkyan* and *thabybyu* appear to be the most refractory species which have been met with as they have a marked tendency to split, check and twist very badly.

Girdling Department.—A working plan for a study in girdling under the title "Field study to determine progress of seasoning in Girdled Trees" has been developed, the plan approved, and the experiment is now under way. Two districts have been selected for this experiment, the Satpok Reserve in the Tharrawaddy Division and the Yeni Reserve in the Pyinmana Division. In the Satpok Reserve the following six species are under test :—

Teak, *in* (*Dipterocarpus tuberculatus*), *ingyin* (*Pentacme suavis*), *kanyin* (*Dipterocarpus turbinatus*), *hnaw* (*Adina cordifolia*) and *myaukchaw* (*Homalium tomentosum*).

In the Yeni Reserve eight species are under test ; teak, *in*, *kanyin*, *hnaw*, *thitya*, *padauk*, *pyinma* and *leza*.

The data are incomplete, and results have not yet been analysed.

• *Analysis of Results.*—A report has been prepared by Mr. Teesdale under the title "A note on the Seasoning of Burmese Timbers," which gives the results of the experiments which have been completed, and also covers many other subjects, such as, natural and artificial seasoning in Burma, methods to be adopted for commercial practice, cost of seasoning, analysis of results of girdling study, etc.

(iv) *Seasoning Sheds.*—Seasoning sheds are to be built in which material may be seasoned naturally to confirm data obtained in other experiments, and to determine the period required for seasoning various species and dimensions.

(v) *Wood-Working Workshop.*—Lacking a suitable workshop where seasoned material may be worked up into finished wooden products, it has been impossible to carry the analysis of seasoning experiments to a complete stage. It is not sufficient to know that rough timbers may be successfully seasoned, as the after effects of climatic influences have such an important bearing upon the suitability of timber for specific uses. Only by observing properly

seasoned material during and after its manufacture into finished products will it be possible to determine the suitability of the seasoning method, determine the potential value and exploit such timbers to their best advantage. Study and observation in the workshop is as important as the experimental work in the dry kilns and seasoning sheds.

Despite the absence of an equipped workshop very useful work has been done by Mr. A. Cogger, Foreman Turner, with a gang of Chinese carpenters on furniture-making; and the new School of Forestry in the Rangoon University has been largely equipped with furniture constructed under his supervision from various Burma hardwoods. He has also been engaged on making furniture for the research branch at Maymyo (Silviculturist) and the way in which these articles stand will be closely observed and will afford valuable data. In this connection it may be noted that various Burma hardwoods, principally *padauk*, *thitsi*, *hnaw* and *thitkado*, were supplied to Messrs. Whiteaway, Laidlaw and Company, for furniture manufacture. Their manager in this Department has constructed some excellent pieces of furniture, and is confident that there are opportunities for very great expansion in this business.

(vi) *Tans*.—A bale of finished leathers was received from Mr. J. A. Pilgrim, Tanning Expert to the Government of India. These leathers were tanned by Mr. Pilgrim and his staff at Maymyo with Burma hill tanstuffs during his stay at Maymyo, and various dressings to convert the pieces into uppers, harness leathers and ordinary sole leathers have been applied by Messrs. W. B. Shewan and Company, Cawnpore. The hides were tanned with one agent only and not by mixed tannage.

(vii) *Timber Testing*.—During the year under report 12 specimen planks of *hza* (*Lagerstroemia tomentosa*) and 12 planks of *kanazo* (*Heritiera Fomes*) were despatched to the Forest Economist, Dehra Dun, to enable him to carry out experiments as to their suitability for sucker rods. The tests on the suitability of *Heritiera Fomes* for sucker rods are complete and they indicate that it is suitable in every way without any alteration to the design of the coupling. Tests on *taukkyan* (*Terminalia tomentosa*) show that it can also be used provided an extra rivet is put in the strap. Steps are now being taken for a sample set of 200 or 300 sucker rods of each of the above species to be manufactured at the workshop for a thorough field trial by the Indo-Burma Petroleum Company.

At the instance of the Forest Economist, Forest Research Institute, Dehra Dun, 1 log each of *myawhchar* (*Homalium tomentosum*) and *thitkado* (*Xylocarpus dolabriformis*), were tied together and placed in the Rangoon River on November, 1922, and one log of teak (*Pectonea grandis*), on the 24th November, 1922, with a view to ascertaining their respective powers of resistance to attack by Teredo and other marine borers.

The logs were removed from the river after 3 months for examination, and were replaced for further examinations. The result of the examination is as follows :—

- (1) The *pyinkado* log was almost entirely covered with holes $\frac{1}{8}$ " diameter more or less evenly distributed over the surface of the log.
- (2) The *myaukchaw* log was slightly attacked at one place only ; a small patch at one end of the log was covered thickly with tiny pin holes, in some parts developing into larger holes similar to those in the *pyinkado* log. The rest of the log showed no sign of attack.
- (3) The teak log showed signs of attack in two places, one about the middle of the log and the other on one end. The stage of development appeared very similar to that in the case of *myaukchaw*.

(viii) *Miscellaneous*.—With the transfer of the Conservator's Office from Phayre Street to the present building the Forest Museum was also transferred and placed on the ground floor of the building. The space here too is not sufficient, and consequently the heavy timber specimens have been stored. The other exhibits have been placed in the Conservator's Office and are open to the public.

CENTRAL PROVINCES.

Utilization.

I.—General Work of Administration.

Allapilli—departmental working to be increased.

II.—Experimental and Commercial activities.

(1) Minor Forest Products—Lac.

Ghont—Lac (*Zizyphus xylopyra*).

The main crop of lac in Damoh this year fell considerably short of the estimate for reasons variously ascribed to the untimely late rains ; alterations in methods of infection ; a disproportionate increase in male lac, etc. The need for a lac working plan (apparently feasible with *ghont*) and the encouragement of experimental work is emphasised by the Divisional Forest Officer. Research work in connection with lac is "the excellence" reflected in revenue, but is extremely difficult to accomplish in conjunction with the heavy administrative burden of a mainly lac-producing Division. With the steady yearly increase in departmental propagation it is essential to ensure that the productive areas are worked not to death but with a view to a sustained annual yield, and it seems likely that a cycle (e.g., 3 years) can be adopted.

Kusam Lac (Schleichera trijuga) South Raipur.

In South Raipur experimental work was continued. On *kusam* (*Schleichera trijuga*) the main lac species here, which unlike *ghout* is not of gregarious habit, a regular cropping scheme is impracticable, as the experience of the past 2 years has shown that however well the propagating work is carried out, the other factors influencing the growth of lac have a much greater effect on the resulting crop. In the early stages vast numbers of insects die, and in the later stages climatic variations form the most serious menace, as no means appear to be able to be devised to combat their effect. There is reason to believe that reinfection of *kusam* trees which have formed a small crop of lac will result in a better crop on subsequent infection.

The actual results obtained during the year have been distinctly diverse. The average crop in July 1922 was poor, chiefly through the mistake of early propagation. In isolated cases astonishingly good results were obtained. The best individual tree, a *kusam* about 60 feet high standing in the half open with a good round crown pruned heavily in August 1920 gave a yield of 2 maunds 35½ seers of brood lac and 25 seers of broken dal lac. The value of the crop of this one tree was about Rs. 250. The propagation work in the rains of 1922 was carried out well. The swarming of the larvæ was excellent, rather less than the average number dying at once. The crop was still apparently healthy in August and early September, but between September and December large quantities died. The only explanation forthcoming is the unusual extensions of the rains into late September and early October. The cold weather yield was little more than the brood used to produce it.

The following facts are worth noting about this crop :—

- (1) Among trees with bushy crowns standing in the open there was little to choose between the results on pruned and unpruned trees. Among forest trees the pruned trees were the best.
- (2) The incrustations were usually big and healthy, but no tree had very many lac-bearing twigs.
- (3) Such lac-bearing twigs were nearly always concentrated on the tree tops.
- (4) Where twigs were in dense masses little lac was obtained; where the twigs were more open the results were better.

It seems that there is evidence to lead one to believe that the cold weather crop is influenced by air circulation. In the propagation work of 1922-23 (cold weather) 1,100 *kusam* trees were infected.

Other species. (South Raipur).

Work on *palas* (*Butea frondosa*) and *ber* (*Zizyphus Jujuba*) continued on a small scale. The investigation into the almost complete failure of *Baisakhi* crops on the *ber* tree was continued; and the theory is now considered conclusively proved that the reason lies in the rising of the sap not corresponding always with the demand for nutrition on the part of the newly fertilised female insect. The female fertilized in February-March dies of starvation when the rising of the sap (evidenced later by the flush of new leaves) is delayed, *e.g.*, till June. It was found in support of this theory that where a good crop of lac is obtained on *ber* in Monbhun and Malder districts, the leaf flush occurs in March-April.

The relative advantages of bundle and stick infection have of late been a particularly vexed question. The lac research officer (Mr. C. M. Harlow, I.F.S.) states that it may be taken as a fact that the use of brood in single sticks gives better results than the use of bundles and that the experience of both methods in the last 2 years' work in South Raipur is sufficient to prove it.

(d) *Miscellaneous.*

A note on the manufacture of *kulha* (from *Acacia Catchu*) was written by Mr. Kesar Singh, Extra Assistant Conservator of Forests. An article on *kurai* tapping was written by Ranger Abdus Salam and published in the "Indian Forester" after the close of the year.

Six discs of *Gardenia latifolia* and *G. turgida* were sent to the Government School of Arts, Lucknow, where they were reported on as being probable substitutes for box wood for engraving. Specimens short lengths of the same species of *Gardenia* were also sent to Messrs. W. W. Howard Brothers and Company for experiment and determination of the differences in these timbers.

ANDAMANS.

No information forthcoming.

COORG.

No information available.

MADRAS.

No information available.

UNITED PROVINCES.

General Work of Administration.

As last year most of the utilization work and the research thereon has been centralised in the Utilization Unit at Bareilly. The bulk of the research work was carried out in the Government Central

Wood Working Institute. At the close of the year this Institute was transferred to the Industries Department, which had formerly originated the concern as a carpentry school. It is not yet known to what extent it will be possible to continue the research work. But from the fact that the Hon'ble Minister for Industries on inspecting the Institute shortly after the transfer expressed himself very pleased with it and desired that so far as funds permitted all the present activities should be continued, it is hoped that the present valuable work will not cease.

In the Legislative Council and the Forest Advisory Board considerable pressure was brought to effect the conversion of the two Government factories at Clutterbuckganj—the Rosin and Turpentine Factory and the Sawmill and Turnery—into public commercial concerns. The former as is well known has been continuously a paying concern, but the latter is still in the early troublesome times of a pioneer enterprise. Steps have been taken to carry out the wishes of the Legislative Council in this matter, and negotiations are well advanced for the conversion of the above two concerns into Limited Liability Companies in which Government will retain a very considerable interest. It says much for the progress of the work done recently at the Sawmill and Turnery that it has been possible to convince commercial men that the difficulties of the past in no way indicate that there is intrinsically anything unsound in the proposition of making bobbins in India. It appears to remain now only for the Forest Department to give the company a sound guarantee regarding the timber required, and the production of bobbins in India on business lines will be assured.

The Rosin and Turpentine Factory required little advertisement, but negotiations regarding the company promotion have been protracted. Labour rates have risen very high in Kumaon, the source of the crude resin, thereby placing the industry at a great disadvantage compared with the Punjab. This increased cost of the supply of the crude product naturally reduces the royalty and profits, which can be obtained on the same by the Forests, and has caused some disappointment to territorial officers.

The Timber Supply Division developed very largely during the year and was of very great assistance in bringing the consumer and the supplier into touch. The sleeper industry expanded considerably as a result of the activities of this agency, with results most beneficial to the revenues of the Province. It is very greatly to be regretted that as a matter of retrenchment it has been decided not to retain the special temporary officer who has formed and made a success of this charge. The work is of a nature for which the normal Forest Officer is not usually well suited, and a possible method of retaining the valuable services of this agency is under consideration.

An important point that has to be faced with regard to research work in the future is the provincialisation of forest interests

under the new conditions. As an example of this it may be noted that a neighbouring province found itself unable to give us information regarding a new type of turpentine distillation plant which it is installing; and in our turn this Province was unable to carry out experimental work for them on a certain timber. It is regrettable but it is difficult to see how this can be avoided under present conditions when commercial interests and provincial revenues are involved.

NOTE.—The obvious course as far as experimental work on timber is concerned is for all Provinces to send their work to the Central Institute at Dehra Dun, which is fully equipped for the purpose, and which exists for the purpose, *inter alia*, of helping Provinces in matters of this kind.

II.—Experimental and Commercial Activities.

(i) Wood Technology.—Nil.

(ii) *Timber Seasoning*.—At the Sawmill and Turnery improved facilities for seasoning blanks for bobbins have been installed, and large stocks of seasoned blanks can now be carried. This affects economy in enabling blanks of the correct size to be used for any order, and enable demands to be met without delay and from thoroughly reliable and seasoned wood. At the Wood Working Institute artificial kiln-seasoning was one of the main items of experimental work. The second kiln was completed during the year, incorporating some improvements as the result of experience gained. The work was to some extent limited by the lack of funds, but 73,000 square feet of boards varying in thickness from $\frac{1}{2}$ inch to 2 inches were seasoned of twelve varieties of timber. Kiln-seasoning charts were made for seven of these timbers. In addition small quantities of seven other kinds of timber were treated. Moisture contents were reduced from 50 per cent. or over to 8 per cent., and sometimes even to 5 per cent., depending on the purpose for which the timber was required. One of the most successful examples was the manufacture of 500 feet run of 30 inches diameter stove piping of *semal* (*Bombax malabaricum*) wood carried out at the request of the Public Health Department for an experiment in wooden piping. The timber was received in log form, and contained about 120 per cent. moisture; the logs were sawn up into planks, kiln-seasoned, finished by machine and despatched within a month. In the seasoning the moisture content in 2 inches planks was reduced to about 10 per cent. in 10 days and no loss in seasoning whatever resulted. One inch *shishum* (*Dalbergia sissoo*) can be seasoned from 45 per cent. to 5 per cent. moisture in 10 days; and *Terminalia tomentosa* from 75 per cent. to 5 per cent. in 18 days, and the dark streaks which are the beauty of this timber in panelling are markedly deepened. Few timbers showed great difficulties in seasoning. Of these *jhinga* (*Olinia*?) is most refractory, and its future lies in uses in which retention of a long period of its moisture is desirable. *Tun* (*Cedrela*?) appears to have two distinct varieties, of one the timber offers no great difficulty in seasoning, of the other with most careful treatment collapse of the timber appears almost

inevitable to a degree equal to the most typical example of the text book.

In connection with the kiln-seasoning work records are kept of daily temperatures and humidity ; also of the corresponding moisture contents of some 37 specimens comprising 11 kinds of timbers, kiln and air-seasoned, uncovered and protected by varnish, etc. Also in special racks the seasonal warping shrinkage and swelling of some 100 specimens including 11 species of timber are being kept under observation. These specimens are air and kiln-seasoned, sawn both radially and tangentially, and are coated in three different ways. These experiments required to be maintained for some time yet before the results can be relied upon ; but should in another year or so give information most valuable as a guide to the uses for which the timbers are suitable and their correct method of treatment. Enquiries continue to be received regarding kiln-seasoned timber, the latest being for timber to be used in ornamental constructional work at Delhi.

(iii) *Timber Testing*.—Little of this is done, as it is considered the sphere of the Forest Research Institute ; but at the Wood Working Institute in connection with the kiln-seasoning work specific weights of different kinds of wood at different moisture contents were determined and tests made to find the difference in the strength of timber after seasoning.

(iv) *Wood Preservation*.—A small experimental unit for creosoting sleepers has been set up by the Timber Supply Officer with the help of the Assistant to the Wood Technologist. The intention is to start in a very small way and get sleepers, already accepted by Railway Engineers from the timber point of view, treated and the treatment accepted by the Railway authorities. Then it is intended if results justify this to expand the work and treat and so utilise a considerable stock of timber now in hand. Thus it is hoped that actual results obtained will give us information regarding costs, enable us to test the market, and eventually induce private enterprise to take up the business.

(v) *Minor Forest Products*.—(a) *Resin*. The manufacture of rosin and turpentine from the resin of *Pinus longifolia* has been continued at the Government Turpentine and Rosin Factory, Clutterbuckganj, which it is hoped shortly to convert into a limited liability company in which Government will retain a large interest. Improvements in the plant have been continued and important parts of one unit have been obtained from France. The record grade of rosin as yet produced in this province—W. G.—and better was obtained on occasions during the year. The record outturn of turpentine was also obtained, but was not maintained in the averages owing to the indifferent quality of much of the crude resin supplied. Further experiments to float out crude resin have not proved successful.

(b) *Lac*.—As mentioned last year experimental cultivation is being energetically taken up in the Jhansi Division. Shortage of seed lac and damage by monkeys and squirrels have been initial difficulties somewhat restricting work; but from 5,500 trees infected in November 1922, it is hoped to treat some 25,000 in June 1923 and 100,000 in the following November. It is however too early as yet to discuss the success of the operations.

(c) *Chir Tar*.—The demands for this have been very poor during the year and the consumption of the crude product appears to be small in India, not averaging over Rs. 1 lakh in value per annum. Manufacture has been closed down during the year owing to sufficiency of unsold stocks. At the close of the year an expert was appointed in the Central Almora Division to overhaul the distillation kilns and the process of manufacture. There appears however little future at present for this product, unless some new use for it is discovered.

(d) *Miscellaneous*.—Attempts are still being made to interest private enterprise in the red and yellow ochres of South Banda and in the exploitation of tufa limestone. It is hoped that experts will shortly investigate these deposits.

(vi) *Paper-Pulp*.—Nil.

(vii) *Tans*.—Oak (*Quercus incana*) bark was supplied from Naini Tal to the Technological Institute, Cawnpore.

(viii) *Wood Working*.—(a) *Turnery*.—It is hoped that the Government Sawmill and Turnery, Clutterbuckganj, will be shortly converted into a public limited Bobbin Manufacturers Company. So far as the present scope of this factory has been developed, it has been considerably brought up to date in the past year and the equipment in certain lines is probably equal to the best found in European factories. The products are good and the timbers used have now had sufficient actual trial in the mills to decide their suitability. It is admitted that this Government has spent large sums on this pioneer enterprise, but the advantages to India of initiating and successfully establishing a bobbin-making industry will be very far reaching. This will be appreciated when it is noted that the average value of imported bobbins in the past three years has been Rs. 80 lakhs, a figure which rose in 1921-22 to Rs. 120 lakhs; at the same time practically no bobbins have hitherto been manufactured in India.

Experimental turnery work has been continued at the Wood Working Institute. Various timbers have been tried for new classes of bobbins. With the establishment of the new Bobbin Company all work of this nature should be carried out by them, but it will pay the Department to give supplies of timbers on which experimental work is desired. Police batons are now made at the Wood Working Institute of *bakli* (*Albigoissus latifolia*) and are believed to be very suitable and practically unbreakable. Over

600 were supplied to the United Provinces Police. Over 50,000 tool handles of various kinds were turned and as often stated before there is a considerable opening for this work. One of the most interesting items of work of the year has been the supply of cutting blocks and boot trees from *jhigna* (*Odina Wodier*). An order for 250 of the former and 2,000 of the latter is well in hand. The variety of other articles produced will be judged by the following list—brush-handles also backs and boards, dumbbells, Indian clubs, cricket stumps, golf-club handles, wooden containers, crayon cases, pencil and chalk boxes dovelling, bed-chair and table-legs, teapoy tops, dumbwaiters, drawer knobs, etc. Shuttle blanks are also under experiment, and the discovery of a suitable wood and of suitable treatment for it is most important.

(b) *Cooperage*.—Considerable experimental work has been done and it has been ascertained that prejudice against Indian timbers has been hitherto largely due to the want of skilled supervision in India in this branch of work. However at the moment it is doubtful if there is any very great opening in India for this trade. 147 casks were made of 10 kinds of timber ranging from Hogsheads (54 gallons) to Kilderkins (18 gallons). In addition other articles ranging from a 100 gallon *haldu* vat to bath tubs, palm stands and buckets were made. *Terminalia tomentosa* (*asna*), on which the greatest hopes were placed, has not proved satisfactory though tried under all varieties of seasoning. Oak (*Quercus dilatata*) is the most promising timber tried. It is available in fair quantities, but extraction is costly and on this factor mainly depends the possibility of its use. The timber for the experiment was converted and riven into bolts at the site of felling under the supervision of the cooperage expert. It was then brought down to the Institute and recut into staves and headings. The timber proved quite easy to dress and shape, and after raising and setting the staves remained rigid. The timber kiln-seasons without much waste due to checking. Subsequent tests for acidity and colouring gave practically negative results. A hogshead has been despatched to an Indian brewery and is believed to be considered satisfactory. Sample sets of staves and headings have also been sent to England, and have been mentioned in the trade papers. Sal makes a very good cask but acidity and taste necessitate lining. *Stercospermum suaveolens* (*padal*) shows great promise. Sixty pulp casks of *haldu* (*Ailina cordifolia*) were made for the fruit pulp industry, and proved very satisfactory. Ten made of *Hymenodictyon excelsum* coopered up well and showed no leakage with cold water, but sweated when filled with hot lemon pulp.

(c) Furniture-making continued to be the main work of the Wood-Working Institute. Seven hundred and twenty-three orders of the value of Rs. 87,173 were carried out, in addition to 83 sample orders not charged for. Three hundred and sixty-six new designs were prepared for customers and enquiries, and 3,600 prints and photographs were distributed. A catalogue with line block prints

and specifications is under preparation. The Institute has done much to improve the quality of the Bareilly furniture work and would have justified its existence by this alone. Various new timbers are under trial in particular *Terminalia tomentosa*.

(d) *Miscellaneous wood work.*—Standardised machined products have been manufactured in considerable quantities and sold to the local trade. In fact many orders in Bareilly could only be accepted because of these facilities. Such products include mouldings, dowellings, picture framings, cornices, match boarding and door and window stock, etc. Electric casing and capping from *Terminalia tomentosa* has been supplied in considerable quantities in Delhi, Naini Tal, Lucknow, etc., and has proved a useful substitute for teak. Experimental wood block floorings in *haldu* and *asna* and secret fixed flooring in *haldu* and panelling in *asna* have been carried out and are now under observation. The *asna* (*Terminalia tomentosa*) panelling looks very promising, and it must be remembered that it is the specially kiln-seasoned and treated variety of this timber prepared and supplied by Messrs. Howard Brothers which has been already extensively used for panelling, etc., in some of the most important buildings in London. There seems every prospect of the development of its use for similar purpose in India, but before it is recommended without reservation, its behaviour under the extremely trying climatic condition of India must be observed. One thousand pounds of wood wool were supplied to the Kumaun orchards for fruit packing. It is believed that the use of this material for packing results in the fruit arriving in much improved condition.

The example of the Wood Working Institute in regard to the development of the use of wood-working machinery is at last being followed in Bareilly, and a company has been formed which is laying down machinery on an extensive scale. This should shortly be in a position to take up and develop many of the lines of manufacture which the Institute has proved on an experimental scale. Its formation is one of the most gratifying proofs of the success of the work of the Wood Working Institute, and bids fair to open a new era in the local wood working trade.

PUNJAB.

In the Utilization Circle a series of experiments were carried out during the year. With the co-operation of some of the more far-seeing timber traders in the Punjab an expert in timber preservation was got out from England. In co-operation with the Forest Research Institute, Dehra Dun, the principal coniferous timbers of the Punjab were experimentally treated with a view to starting a timber-preservation plant in the Punjab. The plant would have produced treated pine sleepers for the Indian railways, and would have extended the utilization of fir, spruce, *chir* and blue pine timber in India, the supplies available being at present greatly

in excess of the demand. The Railway Board, however, was unable to give a definite guarantee of assistance in the shape of orders and so the Syndicate was wound up and the expert allowed to proceed home, as trade conditions at present prevailing made the scheme too risky without definite offers of help from consumers. Messrs. the Surma Valley Saw-mill Company, Limited, carried out experiments for the Utilization Circle, in making veneer from *Populus euphratica* (the "ban" of the Indus River plains tract) and *Populus ciliatá* (the "hill poplar") with satisfactory results, opening the way to the commercial investigation of a three-ply wood industry in the Punjab. Further experiments in the utilization of fir, spruce and blue pine timber for match-making were made in London, with the result that a project for a large factory on the Beas river is well advanced. The factory will be managed and worked by private enterprise. Fir, spruce and blue pine timber have been tested in Europe for sulphite and kraft pulp; and here again the experimental results obtained justify further investigation and trial on a commercial scale. An experiment is in progress for testing mulberry timber from the Punjab irrigated plantations for making textile implements such as picking arms, tubes and bobbins. Reports, so far, are encouraging and steps have been taken to carry out exhaustive tests in England. Mulberry is on the increase in the irrigated plantations and an outlet for the surplus stock is desirable.

At the Jallo Rosin and Turpentine Factory experiments were continued in the preparation of rosin oil from rosin and lamp black from rosin waste. There is nothing to prevent manufacture on a commercial scale except the poor market conditions at present prevailing in India and elsewhere.

Among minor experiments and enquiries may be cited the utilization of mulberry and *shisham* wood for bent-wood furniture, the use of blue pine and spruce timber for electric battery casings, and spruce timber for ferro-concrete shuttering.

It is now obvious that intensive propaganda work is necessary to find markets for the very large supplies of spruce, fir and blue pine timber available in the forests of the North-West Himalayan tract of the Punjab.

MADRAS.

No information forthcoming.

THE LARGE HEARTWOOD BORER OF SAL.



1. The Cause : Felling refuse left in the forest after removal of the timber.
The heartwood borers breed in this material and attack fresh trees in the following year.



2. The Result : Sal beams and poles riddled by the large heartwood borer (*Hoplocerambyx spinic*).
These have been cut from logs seasoned with the bark on.
The Remedy : Clean up the felling-refuse and bark the timber logs before the beginning of the ra

CHAPTER V. FOREST ENTOMOLOGY.

CENTRAL INSTITUTE.

The year 1922-23 has been relatively unfavourable for progress on the biologic and economic sides of Forest Entomology. The uncertainty of the financial position of the Branch, particularly with regard to funds directly expendable on experimental work; the mutability of the proposals to transfer the Branch from its present quarters to accommodation in the new Institute buildings; the indecision as to the future of the unfilled sanctioned posts of Divisional Entomologists; the absence of the Forest Entomologist on six month's leave, combined with the non-appointment of a technical officer to succeed in the vacancy,—all contributed to retard progress.

Insects of sal.—(a) The large heart-wood borer. In Thano forest near Dehra Dun the separate enumeration of sal trees attacked by *Hoplocerambyx spinicornis* has been continued with a yield of 4,411 for the season 1922-23. This quantity represents the recognisable portion of the attack of 1922 plus the over-looked portion of the attack of 1921. As the markings must be carried out at the end of the rains, when the attack is not fully developed, some of the less heavily attacked trees are not detected until after their death in the following year. The annual yields obtained since 1916-17 are as follows:—6,772; 10,190; 23,545; nil; 3,855; 5,821. 4,411. As these figures do not represent the actual annual attack an attempt has been made to arrive at the correct values; these appear to be 8,000 for 1920, 4,000 for 1921 and 2,500 for 1922. In the period 1920-21 control measures were instituted, the effect of which would first be visible in the attack of 1921. Since the rainfall has increased annually since 1919 it is believed that its effect has been counteracted by the remedial measures, and that the epidemic is now completely under control. An attempt to estimate the financial loss due to the attacks of the borer has not been successful owing to the great fluctuations in the prices realised at timber auctions for clean and damaged timber, and absence of any basis for comparison. Moreover it does not seem possible to arrive at an idea of the silvicultural damage, although a revision of the working plan is in progress.

The Thano borer outbreak illustrates very aptly the present position of forest insect control in India. The entomological side of the problem starts with the application of general principles based on the forest entomology of Europe and North America, which soon give place to new conceptions arising from acquaintance with local conditions. The control measures suggested are mainly theoretical, and, as they necessarily involve extraordinary expenditure or departure from routine, are adopted by the departmental executive with reluctance. If applied thoroughly the results are measurable with great difficulty, and, finally, if the control measures can be demonstrated as successful, the cost of application and the value of the damage prevented cannot be calculated.

In the laboratory and insectary experiments were conducted on the emergence period of the borer and length of life, etc., under varying conditions of temperature and humidity. Owing to the absence of the Forest Entomologist and the employment of the Upper Grade Assistants on educational work the results were unsatisfactory.

(b) A survey of the borers of sal with reference to their geographical distribution and alternate food-trees was made. In the families *Scolytidae*, *Platypodidae*, *Cureulionidae*, *Brentidae*, *Anthribidae*, *Bostrychidae*, and *Longicornia* over sixty species are identified as sal borers. Of these 45 per cent. occur also in the Malay Archipelago, 60 per cent. in Indo-China, 100 per cent. in Assam and Bengal, 85 per cent. in submontane region of the United Provinces, 57 per cent. in Central India, 38 per cent. in South India and Ceylon, while 27 per cent. are extra-oriental. These results are sufficient to show that the study of the borers of *Shorea robusta* cannot be restricted to conditions in the sal habitat, but involves other forest types and timber species elsewhere in British India. Very few species are confined to sal, or to parts of its habitat, and these monophagous species are not necessarily important as pests. The composition of the borer-fauna at any part of its habitat is a function of the locality, i.e., the ecological conditions of the environment are of greater importance in deciding what species of borers occur than in the presence of sal as a food supply.

Insects of teak.—Teak insects have received no attention during the year. The special investigation of the beehole borer carried on by Mr. J. M. D. Mackenzie, was concluded by his departure on six months' leave, and by the decision of the Government of Burma not to re-open the enquiry. The chief results obtained from the enquiry are :—(1) the abundance of the pest varies greatly in neighbouring areas and in successive years ; (2) natural control factors periodically bring the local annual incidence almost to zero, but on the whole the mean annual incidence slowly increases ; (3) the increase is relatively greater in the past 20-30 years in both plantations and natural forest, but there are indications of a general decrease quite recently. No explanations of universal application can be given for the fluctuation in abundance, and, in particular, the correlation of fire-protection with the conditions mentioned in (3) is neither proved nor disproved. The silvicultural schemes, providing for early and frequent thinnings in plantations, etc., afford a means of producing periodic reductions in the abundance of the pest, and there is reason to believe that large clearances for regeneration can be utilised to afford a heavy initial check.

Future investigations should determine the comparative effect of thinnings, the possibility of retarding the infestation of concentrated regeneration areas, the value of alternate hosts as trap crops, and the effect of fires. The value of the work already done on this pest is much invalidated by the absence of reliable historical records for the forests sampled, and we are therefore compelled to wait for the future to supply accurate histories. Until a whole-time investigator is available to maintain continuous observations no progress

can be anticipated. Meanwhile some thousands of acres of teak regeneration are being formed annually in which the pest is establishing itself with far greater rapidity than it did in the nineteenth century.

Miscellaneous Pests.—The Borers of timber under seasoning.—Work on this subject was continued in the Insectary; the yield of bred specimens is greater than the setting staff can cope with; identifications are considerably in arrears. Before the results of this investigation can be summarised a great deal of naming-up of material has to be done, so that progress is dependent on the services of a systematist.

Dry Wood Borers.—A study of the life cycle of *Stromatium barbatum* was commenced; the emergence period for 1922 was determined and artificial infections with eggs were started. The effect of repellants on oviposition was tested.

General Insectary Work.—Enquiries from the department were accompanied by 97 consignments of specimens for examination. Material was also received from the Indian States, Federated Malay States, Siam, Ceylon and Australia. About 9,000 specimens were reared in the Insectary.

Tours.—Owing to the necessity for economising no investigations were carried out in the forest by the Forest Entomologist. A Senior Assistant was sent in his place for six weeks to collect information in the sal forest of the Central Provinces. The 4th Entomological Meeting held at Pusa in February 1923, was attended by Dr. Beeson, who read papers on the "Geographical Distribution of Sal Borers" and "Recent Work in Forest Entomology."

Systematic Entomology.

The Insect Collection.—The growth of the collection of forest insects during the year exceeded previous records. A total of 752 species not previously represented were added, including 26 novelties which are represented either by types or by cotypes. Nearly 16,000 specimens were mounted and labelled, of which 6,235 specimens were sent abroad to specialists for determination. The entomologists who have given their services on behalf of the Institute are Drs. Arrow, Blair, Marshall and Obenberger, Messrs. Andrews and Champion, M^{ons}. Flentiaux, Desbordes and Lésne, Herrn Kleine, Corporeau, and Col. Winn-Sampson for *Coleoptera*; Dr. Waterston, Messrs. Crawley and Turner and Rex. Morice for *Hymenoptera*; Messrs. Tothill and Senior-White, and Miss Ricardo for *Diptera*; M. Esben-Petersen for *Neuroptera*; Prof. Silvestri for *Isoptera*; Major Beeson for *Orthoptera*; Messrs. Fletcher Meyrick and Tams for *Lepidoptera*; Mr. Green for *Hemiptera*.

Dr. Cameron has worked especially at the revision and expansion of the following families:—*Staphylinidae*, *Erolyidae*, *Endomychidae*, *Colydiidae*, *Blatridae*, *Tenebrionidae*, *Brentidae*, *Nymphalidae*, *Papilionidae*, *Pieridae*, and *Chalcidae*; Dr. Beeson has dealt with the *Scolytidae*, *Platypodidae*, and *Bostrychidae*, Babu Seelendra

Nath Chatterjee has been mainly responsible for the revision of the *Rhopalocera*. In all, over 12,000 specimens of identified insects have been added to the collection in the last twelve months. Exchange of material has been effected between the Institute and foreign entomologists, and other scientific institutions in India, Europe and America. For the accommodation of the growing collection ten 20-drawer store-cabinets and 227 store-boxes were obtained.

General Review of Systematic Work.—Advance on the systematic side of forest entomology during the last two years has been the most satisfactory feature of entomological research. The foundations of a reliable reference collection have been laid on authoritative determinations, provision has been made for the permanent preservation of part of it, satisfactory relations have been established with a host of foreign specialists and institutions, and a very appreciable reduction has been effected in the mass of unnamed materials derived from the Insectary and field surveys. This advance has received a serious check by the breakdown in health of Dr. Cameron, necessitating his departure from India at the close of the year under review. Dr. Cameron commenced work on 4th December 1920. During the two and a quarter years that systematics have received adequate attention 1,786 new species have been acquired (as against 190 species in the previous three years, 1917 to 1920), and about 25,000 specimens have been named and incorporated. Progress in other directions has been proportional.

It is perhaps not realised that systematic entomology, although a purely scientific section, has an appreciable financial value. The money value of the material added to the collection at modern auction prices is about Rs. 6,000. The value of the services of some 30 or 40 foreign specialists given freely throughout the year is far from negligible. At the rate per identification demanded by one specialist the material distributed this year would cost Rs. 4,500 to name. It is difficult to estimate the value of the free publication work done for the Government of India in foreign journals and periodicals. Fourteen separate papers were published in foreign literature by entomologists describing or cataloguing specimens belonging to the Forest Research Institute. To this must be added the saving on free distribution of copies had this information been published departmentally.

Assam.
No information available.

BENGAL.
Specific Investigations.

Miscellaneous Investigations and Records—

(a) Defoliators:

Nil.

(b) Borers.

(c) Seed and Seedling pests, etc., etc.

(d) Other insects.

Preliminary note.—Inspection of *tainyā* plantations in the Darjeeling Division in the early part of this year (1923) resulted in the discovery of widespread attack by *lepidopterous* stemborers. The high degree of infestation found in most areas serves to emphasise the fact that the aggregation of large numbers of trees of uniform age and species is most suited to the multiplication of harmful insects, and that the cost of controlling these insects (when possible) must be allowed for in the future in plantations of this sort.

(1) *Attacking Cryptomeria japonica.*—In the early part of this year (1923) it was found that two-year old to five-year old plantations of *Cryptomeria japonica* were subject to attack by two species of insect, each belonging to a distinct family of *Lepidoptera*. These two species differ slightly in their habits but their work, to put it briefly, consists in girdling and boring in the main stem, with the result that the whole tree dies or the top is killed, according to the distance of the girdle from the ground and the age of the tree. A count showed that about 15 per cent. of the trees in the five-year old plantation in Takdah series are attacked. As there are now 80 acres in this area planted with *Cryptomeria* and the area is being extended annually it is evident that the pests are of considerable importance, especially as intensity of attack is likely to be progressive. The tree is of considerable importance in Darjeeling Division as, while it is useful for tea box planking, it does not suffer from the ravages of deer, etc., to which most other local species are subject. Study of these pests has shown that one is parasitised by a fly (family *Tachinidae*) which will help to some extent to check its spread.

(2) *Attacking utis (Alnus nepalensis).*—Large plantations of *utis* at Mim and Rangirum were attacked by a *Lepidopterous* girdler which, attacking chiefly trees about 5 year old, causes the tops to die above the girdle which may occur at any height on the main stem between 3 ft. and 10 ft. A count at Mim showed 72 per cent. of trees to be attacked, and at Rangirum 50 per cent.

(3) *Other species attacked.*—An inspection of areas planted with other species showed that the following are subject to attacks similar to those mentioned above but at present to a lesser extent:—*Eucalyptus Globulus*, walnut (*Juglans regia*), pipli (*Bucklandia populnea*), lephakawla (*Machilus edulis*), buk (*Quercus lamellata*) phalat (*Q. annulata*).

Investigations are being carried out with the object of (a) determining the life histories, etc., of the pests and (b) finding means of control. It is probable, judging from results of experiments that efficient control methods will soon be available for use on a large scale.

(c) *Seedling pests.* Pipli (*Bucklandia populnea*) is a species of considerable importance as a timber tree in Darjeeling Division, but loses in value as a result of a tendency to irregular branching.

Although much of this branching is obviously due to killing of terminal shoots by frost, the additional presence of an insect causing similar results was suspected. Inspection of *pipli* seedlings in Rangirum nursery showed that the cause of the very prevalent "cut off" appearance of terminal shoots was a weevil (family *Curculinidae*) mining in the stem. This weevil is also common in older trees in some parts of the Division. The life-history of this insect is being investigated with a view to control. It is checked to some extent by parasitic *Hymenoptera*.

(d) *Other insects*.—*Buk* (*Quercus lamellosa*) is subject in some ranges in the Darjeeling Division to the attack of ants, which make small mounds of earth round the base of saplings and completely remove the bark and sapwood, causing the death of the tree. A number of small *utis* and *buk* plants found dead in plantations contained *Ambrosia* beetles, but these had almost certainly entered after the death of the trees, which had been killed by frost. Cockchafer larvae (probably *Lachnosternus intermedia*) are extremely common in many plantations especially at Takdah, where many *Cryptomeria* transplants are killed by them.

BHAR AND ORISSA.

1. *Specific Investigations*.—In addition to the insect (*Clamia variegata*) which was reported last year to be doing damage in the Puri Casuarina plantations two other insects were observed during the year, but have not been identified. One was a leaf-borer which attacked nearly every tree in the plantation, and which caused the part of the leaf attacked to die. The other attacked the bark of the trees, in many cases ringing them completely. No trees as yet have been killed by these attacks.

BOMBAY.

No information available.

BURMA.

No information available.

COORG.

No information available.

ADAMANS.

No information available.

ANDAMAN.

No information available.

CENTRAL PROVINCES.

In the Akola Division, *babul* (*Acacia arabica*) bushes of recent sowings in combination with field crops have been damaged and

often killed by a borer which tunnels in the root and close to the ground. Old stools of teak, especially those which have failed to produce shoots, are also being attacked by a borer. In South Raipur young sal in certain localities have had their main shoots attacked and the leader usually killed. The usual malformation of the new leader is produced, and the damage is attributed to *Pametheristis*. There is some reason to believe that a sucking bug has been at work also. This form of damage may constitute a serious menace to the new silvicultural operations being attempted in the division.

The *Cicadid*, *Platypleura capitata*, swarmed in large numbers in the Sihawa forests in the summer months of 1922, and in large numbers in the Balod forests in 1923, while in the same year smaller numbers were noticed in Sihawa. The *Pentatomid* bug *Tessaratoma Javanica* was identified in an isolated case attacking and causing the death of shoots of *kusam* (*Schleichera trijuga*). In South Chanda the teak defoliator was scarcely in evidence presumably owing to the good and prolonged rains.

PUNJAB.

No information available.

UNITED PROVINCES.

No information available.

CHAPTER VI.

FOREST CHEMISTRY.

CENTRAL INSTITUTE.

The following is a list of the subjects sanctioned for investigation in the Chemical Branch of the Forest Research Institute during the period under report :—

1. Gums, Resins, Oleo-resins and Essential Oils.

(1) General study of essential oils.

(2) General study of gums, resins, oleo-resins, gum oleo-resins and wood oil and natural varnishes.

2. Miscellaneous enquiries.

(1) General enquiry into oil-seeds and their uses.

(2) Investigation into Indian Turpentine.

3. General investigation into the nature and value of dyes obtainable from woods, barks, fruits, flowers and leaves.

The greater portion of the time of the laboratory has been devoted to the study of essential oils. Much of the work has been published during the year so that the results may be given very briefly.

Pinus longifolia.—The terpene $d\text{-}\Delta^8$ Carene from the oleo-resin of *P. longifolia* has been re-examined during the year owing to the results obtained on investigating the chemistry of the isomeric terpene $d\text{-}\Delta^4$ carene isolated from the seeds of *Andropogon Jwarancusa*, Jones. (see below). The results were of considerable interest and have been published (Trans. Chem. Soc. 1923).

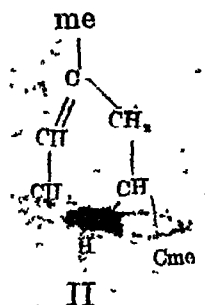
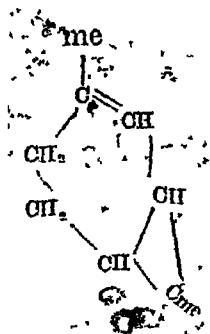
The experiments on the constitution of the sesquiterpene *longifolene* have been continued and data are gradually being accumulated which it is hoped will lead to the elucidation of the constitution of this substance.

A commencement has been made with the study of the rosin from the distillation of the oleo-resin of *P. longifolia*. The "abietic" acid has been obtained pure and is being examined.

Pinus excelsa.—The leaf oil from *P. excelsa* was distilled by Colonel C. R. Johnson at Abottabad and a sample of the oil was placed at the Forest Chemist's disposal for examination. The results of the investigation are in the press (Ind. For. Rec.).

Pinus Gerardiana.—The oleo-resin of this inaccessible conifer was collected and distilled at the Turpentine Factory, Jallo. It yields an excellent turpentine, and the results obtained on its examination form the subject of a paper which is in the press (Ind. For. Rec.) When the turpentine from *P. Merkusii* has been examined (a sample is expected shortly from Jallo) the properties of all the turpentine from the Indian oleo-resins derived from the *Pinus* species will have been studied.

Andropogon Jwarancusa, Jones.—During the investigation of the oil from *A. Jwarancusa*, Jones, a new terpene was isolated which has now been carefully investigated. (Trans. Chem. Soc. 1922, 121. 2292). The results show it to have the formula I (see below) and to be $d\text{-}\Delta^4$ carene. The $d\text{-}\Delta^8$ carene isolated from *P. longifolia* oleo-resin has formula II; and it is of very considerable interest that two terpenes of the carene group, which had not previously been found in nature, should now have been isolated.



Boswellia serrata.—The essential oil from *B. serrata* was first isolated by Pearson and Puran Singh in these laboratories. Ac-

*The results of the investigation are now in press.

According to these authors the oil was an excellent turpentine and consisted mainly of α - and β -pinene. A careful re-investigation has shown this to be incorrect. The principal terpene present in the oil is δ - α -thujene,* a terpene which has not previously been found in nature. A full account of the work, which is somewhat technical, is in the press. (Ind. For. Rec.).

Cupressus torulosa.—The oil from the leaves of *Cupressus torulosa* is under investigation.

Oxidation of Indian turpentine.—An interesting series of experiments is in progress on the rate of oxidation of α -pinene and δ - α -carene in the presence of catalysts. The results are of interest and may lead to a method for improving the keeping properties of Indian turpentine, which at present deteriorates somewhat rapidly.

Fixed Oils.—The oil from *Aleurites montana*, Wils. has been examined in collaboration with Mr. Robertson and Mr. Parker. It resembles but is not identical with that of *A. Fordii*. The seeds of the shrub *Salvia plebeia*, R. Br. yield a semi-drying oil but as the yield of the oil is only 11 per cent. it is not of commercial importance.

Lathyrism.—Some progress has been made with the study of the causation of the disease lathyrism, which is being carried out in collaboration with Mr. Howard of Pisa and Captain Anderson of Kasauli. So far as the experiments go at present it has been shown that geese fed on *L. sativus*, suffer no ill effects, whereas a weed known as "akla" which occurs mixed with *L. sativus* in the crops has marked toxic properties. Whether this fact has any connection with lathyrism in man remains to be determined.

The Forest Chemist visited Lucknow in January to attend the meeting of the Science Congress.

As usual the record of analytical work has been maintained.

Every assistance has been received from both the Research Officers and Officers of the Forest Department, to whom the thanks of the Forest Chemist are due. The absence of an Officer-in-Charge of the Section of Minor Forest Products has been very much felt, and it will considerably handicap the work of this branch if this appointment is not filled by a whole-time officer.

The laboratory is now fairly well equipped for the work, and the library has been much improved, although further expenditure is still required to make it really useful.

ASSAM.
No information available.

BENGAL.
No information available.

BIHAR AND ORISSA.
No information available.

*The results of the investigation are now in press.

BOMBAY

No information available.

BURMA.

No information available.

ANDAMANS.

No information available.

COORG.

No information available.

CENTRAL PROVINCES.

No information available.

MADRAS.

No information available.

PUNJAB.

No information available.

UNITED PROVINCES.

No information available.

CHAPTER VII.

FOREST PUBLICATIONS.

Serial No.	Title.	Author.	Date of issue.
	FOREST RECORDS.		
	<i>Issued.</i>		
1	The Essential Oil from the leaves of <i>Abies Pindrow</i> , Spach.	J. L. Simonsen ..	June 1922.
2	On <i>Ahalidoides</i> (Mainly bred at Dehra Dun from pests of <i>Sal</i> , <i>Toon</i> , <i>Chir</i> and <i>Sundri</i>).	James Watciston ..	August 1922.
3	Results of Antiseptic Treatment of <i>Sleepers</i> .	R. S. Pearson ..	Do,
4	Oils and Fat from the Seeds of Indian Forest Trees, Parts I—V.	M. Gopal Rau and J. L. Simonsen.	September 1922.
5	The Constituents of some Indian Essential Oils, Parts I—VII.	J. L. Simonsen and M. Gopal Rau.	November 1922.
6	Further Experiments in the Air Seasoning of Indian Timbers and General Recommendations as to Seasoning Methods with a chapter on "Damage to Timber by Insects," by C. F. C. Beeson, Forest Entomologist.	C. V. Sweet ..	January 1923.

Serial No.	Title.	Author.	Date of issue.
<i>In Press.</i>			
7	The Constituents of some Indian Essential Oils.—The Essential Oil from the gum-oleo-resin of <i>Boswellia serrata</i> , Roxb.	J. L. Simonsen ..	(Issued in April 1923.)
8	Note on the Possibilities of Camphor Cultivation from <i>Cinnamomum Camphora</i> in Northern India.	S. H. Howard, W. A. Robertson & J. L. Simonsen.	(Issued in July 1923.)
9	The Constituents of some Indian Essential Oils, Parts IX and X.	J. L. Simonsen ..	Do.
10	Note on the Work of Extraction of Broad Gauge Sleepers from Nepal.	J. V. Collier. ..	Issued in November 1923.
11	The Constituents of some Indian Essential Oils, Part XI.—The Essential Oil from the leaves of <i>Cupressus torulosa</i> , Don.	J. L. Simonsen ..	(Issued in September 1923).
12	Oils and Fats from the Seeds of Indian Forest Plants, Part VI.—The Oil from the Seeds of <i>Aleurites montana</i> , Willd., and Part VII.—The Oil from the Seeds of <i>Salvia plectra</i> , R. Br.	R. N. Parker, M. Gopal Rau, W. A. Robertson and J. L. Simonsen. M. Gopal Rau and J. L. Simonsen.	
13	A Sal Yield Table for the United Provinces.	L. A. Smythies and S. H. Howard.	(Issued in December 1923.)
14	The Constituents of some Indian Essential Oils Part XII.—The Essential Oil from the oleo-resin of <i>Pinus Merkusii</i> .	J. L. Simonsen ..	Do.
FOREST BULLETINS.			
<i>Issued.</i>			
1	Volume Tables and Form Factors for Sal (<i>Shorea robusta</i>).	S. H. Howard ..	May 1922.
16	Note on Kindal or Hongal (<i>Terminalia paniculata</i>).	R. S. Pearson ..	February 1923.
17	Note on Thingan (<i>Hopsea glauca</i> , Roxb).	A. Rodger ..	October 1922.
18	Note on Gunjun or Kanyin	W. A. Robertson ..	November 1922.
19	An Investigation of certain factors concerning the Resin-tapping industry in <i>Pinus longifolia</i> .	H. G. Champion ..	February 1923.
20	Classification of <i>Pinus</i>	..	November 1922.

Burma.

The following Burma Forest Bulletins were issued during the year:—

- No. 6.—Rough volume tables for teak, Tharrawaddy Division, by H. R. Blanford.
 - No. 7.—Report on work done between 17th October 1921 and 31st March 1922 on the Beehole Borer Investigation, by J. M. D. Mackenzie.
 - No. 8.—Note on growth of teak and teak plantations in Arakan, by W. S. Powell.
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APPENDIX I.

Administration Report of the Forest Research Institute and College for the year 1922-23 (1st April 1922 to 31st March 1923).

Administration.—The post of President, Forest Research Institute and College was held by Mr. W. F. Perrée, C.I.E., Chief Conservator of Forests, throughout the year.

The names of the officers who held charge of the various branches are given below :—

Branch of Forest Research Institute.	MONTH AND DATE.		Name of officer in charge of branch.
	From	To.	
Silviculture ..	1st April 1922.	5th October 1922.	Mr. H. Trotter, M.C., Deputy Conservator of Forests, Burma.
	6th October 1922.	31st March 1923.	Mr. S. H. Howard, B.A., Deputy Conservator of Forests, United Provinces.
Forest Botany ..	1st April 1922.	12th December 1922.	Mr. R. S. Hole, C.I.E., F.C.H., F.L.S., F.E.S., Conservator of Forests, India list.
	13th December 1922.	31st March 1923.	Mr. R. N. Parker, F.C.H., Deputy Conservator of Forests, Punjab.
Forest Economy ..	1st April 1922.	16th May 1922.	Mr. R. S. Pearson, C.I.E., F.L.S., Conservator of Forests, Bombay.
	17th May 1922.	20th November 1922.	Mr. W. A. Robertson, F.R.G.S., Deputy Conservator of Forests, Burma.
	21st November 1922.	31st March 1923.	Mr. R. S. Pearson, C.I.E., F.L.S., Conservator of Forests, Bombay.
Forest Entomology	1st April 1922.	16th May 1922.	Dr. C. F. C. Beeson, D.Sc., M.A., F.E.S., Deputy Conservator of Forests, Punjab.
	17th May 1922.	5th November 1922.	Mr. W. F. Perrée, C.I.E., President and Chief Conservator of Forests, India list.
	6th November 1922.	31st March 1923.	Dr. C. F. C. Beeson, D.Sc., M.A., F.E.S., Deputy Conservator of Forests, Punjab.
Forest Chemistry.	1st April 1922.	31st March 1923.	Dr. J. L. Simonsen, D.Sc., F.I.C., F.A.S.R.

APPENDIX II.

FINANCIAL.

The expenditure of the past two years is compared below :—

	EXPENDITURE DURING THE YEAR.		Difference + or —.
	1921-22 (12 months, 1st April 1921 to 31st March 1922).	1922-23 (12 months, 1st April 1922 to 31st March 1923).	
	Rs.	Rs.	Rs.
AVI Stores, Tools and Plant ..	1,11,417	58,673	—52,744
AVII Building, etc.	6,841	9,481	+2,643
AIX Miscellaneous	69,069	75,367	+6,298
BIA Conservators	57,090	54,737	—2,353
BIB Superior Officers Non Voted ..	1,81,863	2,03,210	+18,347
BIB Superior Officers Voted ..		37,805	+37,805
BIC Subordinate Forest and Depot Establishment.	3,364	5,994	+2,630
BID Office Establishment	58,672	67,353	+8,681
BIE Deputation and Special allow- ances.	22,500	..	—22,500
BIF Compensation for dearness of provisions.	—4	..	+4
BIJ House-rent and other allowances	..	595	+595
BII Travelling Allowances	31,095	17,234	—13,861
BIII Contingencies	44,561	32,881	—11,680
TOTAL	5,89,468	5,07,333	—82,135

The decrease under AVI is due to smaller expenditure on machinery for the Economic Branch. As the equipment of the Branch approaches completion such expenditure naturally falls.

The increase under AVII is due to the purchase of fans for the main Research Institute building.

The increase under AIX is due to larger purchases of chemicals, and to the extension of experiments in the Economic Branch.

The decrease under BIA is due to Mr. Pearson, Forest Economist, having been on leave for a portion of the year.

The increase under B1b non-voted is due to the special allowances of Research Institute officers having been charged to this head instead of to B1e as formerly ; and also to the appointment of Dr. Brown as Wood Technologist.

The increase under B1b voted is due to the pay of Upper Grade Assistants having been charged to this head, and also to annual increments.

The increase under B1c is due to the appointment of more Lower Grade Assistants in the Economic and Entomological Branches.

The increase under B1d is due to annual increments, and to the appointments of extra temporary establishment in the Economic Branch.

The decrease under B1e is due to the special allowances of Research Institute Officers having been charged to B1b.

The increase under B1g is due to the house allowance sanctioned for the European Carpenter.

The decrease under B1f is due to touring having been restricted for the sake of economy.

The decrease under B1h is due to smaller expenditure on illustrations to publications.

W. MAYES,

President,

Forest Research Institute and College

APPENDIX III.

Annual Form No. 24.

FOREST DEPARTMENT, INDIA, FOREST RESEARCH INSTITUTE DIVISION.
Summary of Revenue of the different Divisions during 1922-23.

BUDGET HEADS.	President.	Sylviculturist.	Forest Botanist.	Forest Entomologist.	Forest Economist.	Forest Chemist.	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. £
REVENUE							
I.—TIMBER AND OTHER PRODUCE REMOVED FROM THE FOREST BY GOVERNMENT AGENTS—							
(a) Timber
(b) Firewood and charcoal.
(c) Bamboos
(d) Sandal-wood
(e) Grass and other minor produce.
TOTAL I
II.—TIMBER AND OTHER PRODUCE REMOVED FROM THE FOREST BY CONSUMERS OR PURCHASERS—							
(a) Timber
(b) Firewood and charcoal.
(c) Bamboos
(d) Grazing and fodder grass.
(e) Other minor produce.
(f) Other items
(g) Commutation fees.
TOTAL II
III.—DRIFT AND WASTE WOOD AND CONFISCATED FOREST PRODUCE.							
TOTAL III
IV.—REVENUE FROM FORESTS NOT MANAGED BY GOVERNMENT—							
(a) Duty on foreign timber and other forest produce
(b) Revenue from shared and private forests.
TOTAL IV
V.—MISCELLANEOUS—							
(a) Fines and forfeitures.
(b) Refunds	134 0 0	11 11 0	1 0 0	..	136 0
(c) Other sources	33 0 0	..	..	47 11 0	1095 7
TOTAL V	167 0 0	11 11 0	1 0 0	47 11 0	1,229 7
GRAND TOTAL REVENUE.	167 0 0	11 11 0	1 0 0	47 11 0	1,229 7

APPENDIX III—contd.

Annual Form No. 24—contd.

Summary of Revenue of the different Divisions during 1922-23.

BUDGET HEADS.	President	Sylviculturist.	Forest Botanist.	Forest Entomologist.	Forest Economist.	Forest Chemist.	TOTAL.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
EXPENDITURE.							
A.—Conservancy and Works.							
I.—TIMBER AND OTHER PRODUCE REMOVED FROM THE FORESTS BY GOVERNMENT AGENCY—							
(a) Timber ..	..	..	..	..	..	..	..
(b) Firewood and charcoal.	..	..	..	..	..	..	..
(c) Bamboos ..	..	..	..	..	..	..	..
(d) Sandal-wood ..	..	..	..	..	..	..	..
(e) Grass and other minor produce.	..	..	..	..	..	..	..
TOTAL A. I. ..	..	..	..	..	..	..	..
II.—TIMBER AND OTHER PRODUCE REMOVED FROM THE FOREST BY CONTRACTORS OR PURCHASERS—							
TOTAL A. II. ..	..	..	..	..	..	..	..
III.—DRIFT AND WASTE WOOD AND CONTIGUOUS FOREST PRODUCE—							
TOTAL A. III. ..	..	..	..	..	..	..	..
IV.—REVENUE FROM FOREST NOT MANAGED BY GOVERNMENT—							
(a) Duty on foreign timber and other forest produce.							
(b) Revenue from shared and private forests.							
TOTAL A. IV. ..	..	..	..	..	..	..	..
V.—RENT OF BLANKET FOREST AND PAYMENTS TO SHANT-HOODS IN FORESTS MANAGED BY GOVERNMENT—							
TOTAL A. V. ..	..	..	..	..	..	..	..

APPENDIX III—contd.

Annual Form No. 24—contd.

FOREST DEPARTMENT, INDIA, FOREST RESEARCH INSTITUTE DIVISION.
Summary of Expenditure of the different Divisions during 1922-23.

BUDGET HEADS.	President.	Sylviculturist	Forest Botanist.	Forest Entomologist.	Forest Economist.	Forest Chemist.	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VI.—LIVESTOCK, STORPS, TOOLS AND PLANT—	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs.
(a) Purchase of cattle	..	..	..	..	..	..	..
(b) Feed and keep of cattle	..	..	..	..	..	..	..
(c) Purchase of stores, tools and plant.	387 0 0	1,050 8 0	906 8 3	6,619 13 4	49,287 4 7	421 13 0	53,672
TOTAL A. VI ..	387 0 0	1,050 8 0	906 8 3	6,619 13 4	49,287 4 7	421 13 0	53,672 1
VII.—COMMUNICATIONS AND BUILDINGS—							
(a) Roads and bridges.	..	..	..	..	..	..	..
(b) Buildings ..	8,540 11 0	..	..	..	..	..	8,540 1
(c) Other works	556 0 0	..	377 13 0	0 8 0	..	..	934
TOTAL A. VII ..	9,105 11 0	..	377 13 0	0 8 0	..	..	9,484
VIII.—ORGANIZATION IMPROVEMENT AND EXTENSION OF FORESTS—							
(a) Demarcation	..	..	..	..	..	..	..
(b) Cost of Forest Settlements; compensation for land and rights	..	..	..	..	..	..	..
(c) Surveys ..	..	..	..	..	..	..	..
(d) Working plans	..	..	..	..	..	..	..
(e) Sowing and planting.	..	..	..	..	..	..	..
(f) Protection from fire.	..	..	..	..	..	..	..
(g) Other Works	..	..	..	..	..	..	..
TOTAL A. VIII ..	..	..	..	..	..	..	..
IX.—MISCELLANEOUS							
(a) Law Charges	..	..	..	..	..	..	..
(c) Other Charges	2,910 13 2	4,189 4 4	1,974 3 1	2,592 4 2	60,787 1 1	6,912 14 7	75,366 8
TOTAL A. IX ..	2,910 13 2	4,189 4 4	1,974 3 1	2,592 4 2	60,787 1 1	6,912 14 7	75,366 8
TOTAL A.—CONSERVANCY AND WORKS.	12,403 8 8	5,239 12 4	3,259 8 4	9,212 9 6	1,06,074 5 8	7,334 12 1	1,47,523 8
B.—ESTABLISHMENTS.							
I.—SALARIES—							
(a) Conservators	17,700 0 0	..	23,011 6 10	..	13,995 13 11	..	54,707 4
(b) Superior Officers N.V.	..	13,456 10 0	18,150 0 0	21,707 15 0	1,32,787 3 6	16,048 5 0	2,03,210 1
Voted ..	5,238 11 0	4,380 0 0	8,700 0 0	8,340 0 0	3,945 12 11	7,140 0 0	37,804 7
(c) Subordinate forest and dept. establishments	..	..	..	3,841 9 0	2,152 10 10	..	5,994 3
(d) Office establishments	11,763 0 7	5,581 8 10	7,040 3 10	10,706 5 0	24,270 12 10	6,006 12 0	67,353 1

APPENDIX III—*concl.*Annual Form No. 24—*concl.*Summary of Expenditure of the different Divisions during
1922-23—*concl.*

BUDGET HEADS.	President.	Sylviculturist.	Forest Botanist.	Forest Entomologist.	Forest Economist.	Forest Chemist.	TOTAL.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
B.—ESTABLISHMENTS—<i>concl.</i>	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
I.—SALARIES—<i>concl.</i>							
(a) Deputation and special allowances.	..	..	..	..	..	..	..
(f) Grain compensation allowances.	..	..	..	..	..	..	..
(g) House rent and other allowance.	..	..	..	..	505 0 0	..	505 0 0
TOTAL B. I. ..	34,721 11 7	21,418 2 10	57,807 10 8	41,715 14 0	1,78,747 0 0	20,109 6 0	3,50,694 6 1
II.—TRAVEL AND ALLOWANCES—							
(a) Conservators	800 11 6	..	237 10 0	..	721 10 0	..	1,815 15 6
(b) Superior Officers	7 8 0	2,667 11 0	500 2 0	1,257 13 0	7,320 7 7	318 8 0	11,978 1 7
(c) Subordinate forest and depot establishments.	..	..	..	..	472 5 0	..	472 5 0
(d) Officer establishments	..	932 5 8	200 10 4	282 7 0	1,767 6 2	28 0 4	2,987 6 6
TOTAL B. II. ..	814 3 6	3,260 0 8	1,034 6 4	1,540 4 0	10,181 12 0	347 1 4	17,233 12 7
III.—CONTINGENCES—							
(a) Stationery ..	..	31 2 0	51 0 0	80 11 0	127 4 0	28 13 0	294 14 0
(b) Carriage of tents and records.	..	562 2 0	97 0 0	122 13 0	80 11 0	..	871 13 0
(c) Rents, rates and taxes.	682 8 3	..	56 0 0	..	1,860 0 0	..	2,787 8 3
(d) Mental charges	1,427 0 0	..	218 15 0	61 5 0	160 10 0	..	1,863 15 3
(e) Grain Allowances to menials	..	..	..	..	..	..	..
(f) Official postage	500 5 6	118 7 0	600 5 0	322 14 0	728 8 0	200 5 0	2,500 12 0
(g) Office expenses and miscellaneous.	6,821 3 4	750 1 3	2,175 7 1	2,161 2 0	5,119 11 0	5,000 0 0	23,213 12 11
(h) Uniform and clothing.	..	92 1 0	112 13 0	161 1 0	316 13 0	82 11 6	767 8 0
(i) Telephone charges.	100 0 0	..	325 0 0	..	755 5 0	..	580 14 0
TOTAL B. III. ..	9,711 1 1	1,595 13 3	3,610 2 1	2,872 14 6	8,789 5 0	6,271 14 0	32,881 2 6
TOTAL B.—ESTABLISHMENT.	45,345 0 2	26,280 0 9	62,622 3 1	46,120 0 6	1,97,718 8 3	26,812 5 4	4,19,809 2 1
GRAND TOTAL OF EXPENDITURE.	67,650 8 10	34,519 13 1	65,980 11 6	58,311 10 0	3,01,792 13 11	47,147 1 5	5,03,332 10 8
SURPLUS OR DEFICIT.	57,660 8 10	34,519 13 1	65,714 2 5	58,339 14 6	3,02,770 0 9	48,099 2 8	5,02,103 8 3

CALCUTTA;

M. N. GUPTA,

The 4th September 1923.

Assistant Accounts Officer.

Certified that the totals of this form as printed in the Forest College and Forest Research Institute Reports for 1922-23 when added together agree with those entered in the Forms for the combined offices as supplied by the Accountant General, Central Revenues, under Article 78 (iii) of the Forest Department Code.

W. MAYES,

President,

Forest Research Institute and College.

APPENDIX IV.

Annual Form No. 27.

FOREST DEPARTMENT, INDIA, FOREST RESEARCH INSTITUTE.

Outstandings and Liabilities on account of Contractors' and Disbursers for the Forest year 1922-23.

Particulars.	DEPARTMENT DEBTOR.			DEPARTMENT CREDITOR.			BALANCE DUE.	
	Opening balance.	Recoveries in Cash and value of supplies and work done during the year 1922-23.	Total.	Opening balance.	Payments made during year.	Total.	To Department (Outstandings).	By Department (Liabilities).
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Agriculturist	..	15,159 3 5	15,159 3 5	131 15 9	15,426 7 2	15,558 6 11	399 3 6	..
Forest Botanist	..	4,250 1 5	4,250 1 5	760 3 2	3,707 13 5	4,458 0 7	287 15 2	..
Forest Entomologist.	..	2,995 11 5	2,995 11 5	622 12 0	2,872 11 4	3,495 10 4	499 14 11	..
Forest Economist.	..	16,361 2 5	16,361 2 5	2,311 14 5	16,545 14 8	18,857 13 1	2,496 10 8	..
Forest Chemist	..	2,652 15 11	2,652 15 11	204 15 9	2,798 6 2	3,063 5 11	419 6 0	..
TOTAL	41,419 2 7	41,419 2 7	4,081 13 1	41,351 7 9	45,433 4 10	4,014 2 3	..

M. N. GUPTA,

CALCUTTA ;

Assistant Accounts Officer.

The 4th September 1923.

Certified that the totals of this form as printed in the Forest College and Forest Research Institute Reports for 1922-23 when added together agree with those entered in the Forms for the combined offices as supplied by the Accountant General, Central Revenues, under Article 78 (ii) of the Forest Department Code.

W. MAYES,

President,

Forest Research Institute and College.

APPENDIX V.

List of Forest Publications issued since the creation of the Forest Research Institute, Dehra Dun.

	PRICE (exclusive of packing, postage, etc.). Rs. A. P.
I.—BULLETINS (OLD SERIES).	
1.—Note on the Bee-Hole Borer of Teak in Burma, by E. P. Stebbing	0 4 0
2.—Note on the Quetta Borer (<i>Molesthes santus</i>), by the same author	0 8 0
3.—Note on the Chilgoza (<i>Pinus Gerardiana</i>) Bark Boring Beetles of Zhob, Baluchistan, by the same author ..	0 8 0
4.— <i>Ficus elastica</i> : its natural growth and artificial propagation, with a description of the method of tapping the tree and of the preparation of its rubber for the market, by E. M. Coventry	0 12 0
5.—Notes on a Visit to some European Schools of Forestry, by E. P. Stebbing. (<i>Out of print</i>)	2 0 0
6.—Memorandum on Mechanical Tests of some Indian Timbers, by W. H. Everett	0 2 0
7.—Note on the Chilgoza Forests of Zhob and the Takht-i-Suliman, by E. P. Stebbing. (<i>Out of print</i>)	0 12 0
8.—Note on the Life-History of <i>Hoplocerambyx spinicornis</i> (The Singbhum Sal Borer), by the same author	0 9 0
9.—Note on the Influence of Forests on the Storage and Regulation of the Water-Supply, by S. Eardley-Wilmot ..	1 0 0
10.—Note on the Duki Fig-Tree Borer of Baluchistan (<i>Bulocera rubus</i>), by E. P. Stebbing. (<i>Out of print</i>)	0 7 0
11.—On Some Assam Sal (<i>Shorea robusta</i>) Insect Pests, by the same author	1 10 0
II.—LEAFLETS.	
1.—The Sal Bark-Borer (<i>Sphaerotypes siwalikensis</i> Steb.), by E. P. Stebbing. (<i>Out of print</i>)	0 4 0
2.—The Teak Defoliator (<i>Hyblaea pucra</i> , Cram.), by the same author. (<i>Out of print</i>)	0 2 0
3.—The Teak Leaf Skeletoniser (<i>Pyrausta nuchaealis</i> , Wlk.), by the same author. (<i>Out of print</i>)	0 2 0
4.—The Larger Deodar Bark-Borer (<i>Scolytus major</i> , Steb.), by the same author. (<i>Out of print</i>)	0 4 0
5.—The Blue Pine "Polygraphus" Bark-Borer (<i>Polygraphus major</i> , Steb.), by the same author. (<i>Out of print</i>)	0 3 0
III.—PAMPHLETS.	
1.—Note on Utilisation of Khar Forests in Eastern-Bengal and Assam, by Puran Singh. (<i>Out of print</i>)	0 4 0
2.—The Attack of the Bark-Boring Beetle in the Coniferous Forests in the Simla Catchment Area, by E. P. Stebbing. (<i>Out of print</i>)	0 8 0
3.—A Glossary of Forest Technical Terms for Use in Indian Forestry, by A. M. F. Cochrane. Revised and issued as Bulletin No. 4, New Series. (<i>Out of print</i>)	0 4 0

PRICE
(exclusive of
packing,
postage, etc.).
Rs. A. P.

III.—PAMPHLETS—*contd.*

4.—Note on Lac and Lac Cultivation, by D. N. Avasia. (<i>Out of print</i>)	0 2 0
5.—Notes on Sal in Bengal, by A. L. McIntire. (<i>Out of print</i>)	0 4 0
6.—Note on Forest Reservation in Burma in the Interests of an Endangered Water-Supply, by A. Rodger	1 0 0
7.—Note on Andaman Marble Wood or Zebra Wood (<i>Diospyros Kurzii</i> , Hiern.), by R. S. Troup	0 4 0
8.—Note on the Collection of Statistical Data relating to the principal Indian Species, by A. M. F. Caccia	0 10 0
9.—Tables showing the Progress in Working-Plans in the Provinces outside the Madras and Bombay Presidencies up to 31st December 1908, by the same author	0 10 0
10.—Note on Burmese Lezu Wood (<i>Lagerstrœmia tomentosa</i> , Presl.), by R. S. Troup	0 2 0
11.—Note on Carallia Wood (<i>Carallia integrifolia</i> , DC.) by the same author	0 2 6
12.—Note on Petawun or Trincomali Wood (<i>Beria Ammonilla</i> , Roxb.), by the same author	0 4 0
13.—Note on Burmese In Wood (<i>Dipterocarpus tuloculatus</i> , Roxb.), by the same author	1 0 0
14.—Note on Burma Padouk (<i>Pterocarpus macrocarpus</i> , Kunz.), by the same author	1 0 0
15.—Note on the Preservation of Bamboos from the Attacks of the Bamboo Beetle or "Short-Borer," by E. P. Stebbing	0 7 0
16.—Note on the Best Season for Coppice Fellings of Teak (<i>Tectona grandis</i>), by R. S. Hole	0 4 0

IV.—BULLETINS (NEW SERIES).

1.—Note on Calorimetric Tests of some Indian Woods, by Pura Singh	0 2 0
2.—Memorandum on Teak Plantations in Burma, by F. A. Leete	0 10 0
3.—Note on the Relative Strength of Natural and Plantation-Grown Teak in Burma, by R. S. Pearson	0 4 0
4.—Second Edition of the Glossary of Technical Terms for Use in Indian Forestry, by A. M. F. Caccia, revised by R. S. Troup	0 6 0
5.—The Blue Pine Tomicus Bark-Borer (<i>Tomicus Ribbentropfi</i>), by E. P. Stebbing	0 2 0
6.—Memorandum on the Oil-Value of Sandalwood, by Pura Singh	0 2 0
7.—Note on the Chemistry and Trade Forms of Lac, by the same author	0 3 0
8.—Note on some Germination Tests with Sal Seed (<i>Shorea robusta</i>), by R. S. Troup	0 2 0
9.—Note on Resin-Value of <i>Podophyllum Emodi</i> and the best season for collecting it, by Pura Singh	0 1 3
10.—Note on the Bark-Boring Beetle Attack in the Coniferous Forests of the Simla Catchment Area, 1907—1911, by R. S. Hole	0 3 0
11.—A Further Note on some Casuarina Insect Pests of Madras, by V. Subramania Iyer,	0 14 0

PRICE
(exclusive of
packing,
postage, etc.)
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